

No. 7. — *Carboniferous Fishes from the Central Western States.*

By C. R. EASTMAN.

THE present contribution embodies the results of investigations of an extended series of Carboniferous fishes from the Mississippi and Missouri Valley region, and is essentially a continuation of "Some Carboniferous Cestraciout and Acanthodian Sharks."<sup>1</sup> With regard to faunal relations, the subject-matter of the following pages falls naturally into a threefold division. Attention is first claimed by the Upper Carboniferous fish-fauna of Kansas and Nebraska, which is one of great interest palaeontologically and morphologically. The Coal Measure fish-fauna of Mazon Creek, Illinois, is considered next, and the structure of several new and little-known forms illustrated. Last in order of discussion are certain new or little-known species from the Mississippian series, which appear worthy of notice either on account of their morphologic interest, or because of their relations to other well-known forms. The greater part of the material upon which the following observations are based is preserved in the Museum of Comparative Zoölogy at Cambridge, and so far as possible the location of types and figured specimens is given under the caption of the several species, in the case of all those belonging to other institutions.

## I. THE UPPER CARBONIFEROUS FISH-FAUNA OF KANSAS AND NEBRASKA.

Altogether, about fifteen species of Upper Carboniferous fishes have been described from Kansas and Nebraska in the writings of J. Leidy,<sup>2</sup> O. H. St. John,<sup>3</sup> St. John and Worthen,<sup>4</sup> and S. W. Williston.<sup>5</sup> To

<sup>1</sup> Bull. Mus. Comp. Zoöl., Vol. XXXIX., 1902, No. 3.

<sup>2</sup> Extinct Vert. Fauna Western Territ. Rept. U. S. Geol. Surv. Territ., Vol. I., 1873, pp. 311-313.

<sup>3</sup> Hayden's Final Rept. U. S. Geol. Surv. Nebraska, 1872, pp. 239-245.

<sup>4</sup> Palaeontology of Illinois, Vol. VI., 1875; *ibid.*, Vol. VII., 1883.

<sup>5</sup> Kansas Univ. Quart., Vol. VIII., 1899, p. 178.

these must be added also a single tooth of a Cladodont shark from the Permo-Carboniferous of Blue Springs, Nebraska, which is made by Cope<sup>1</sup> the type of his so-called *Styptobasis knightiana*. The Missourian fish-fauna of Kansas and Nebraska consists almost exclusively of Elasmobranchs, and is directly successional to the Lower Coal Measure and Mississippian assemblages occurring throughout a wide area to the eastward of these States, its relations with the Chester fauna of Kentucky, Illinois, and Missouri being not its least striking feature.

During the last few years a considerable quantity of new material has been brought to light, chiefly through the activity of Prof. Edwin H. Barbour, Director of the Nebraska University Geological Survey, and his sister, Miss Carrie A. Barbour, of the State University at Lincoln. The writer owes it to the kindness of Dr. and Miss Barbour that all of the specimens collected by them have passed through his hands, and that a number of them are illustrated in the present paper. Acknowledgments are also due to Dr. S. W. Williston of Chicago University, and to Prof. W. C. Knight of Wyoming State University, for the generous loan of material under their charge. Having these facilities at one's command, it seems desirable to present a synopsis of the trans-Missourian fish-fauna which shall be as complete as the present state of our knowledge permits, and this is the endeavor of the following pages.

The stratigraphy and palaeontology of the eastern parts of Kansas and Nebraska have been studied in great detail by a number of geologists during the last few years with special reference to the question of the homotaxial relations of the so-called Permian beds. The discovery of supposed Permian fossils from this region was first reported by Swallow in 1858, and in the spirited controversy which followed, Meek, Swallow, Hawn, Shumard, Hayden, Newberry, Marcou, Geinitz, and others participated, arguing either for or against the recognition of the Permian as a distinct epoch in North American geology. Later the subject was discussed by White and Broadhead to some extent, and more recently Prosser, Cragin, Cummins, Keyes, Tarr, Haworth, Knight, Darton, and Frech have made important contributions to the literature of the Permian question.

It seems to have been established that there are from 1000 to 1350 feet of fossiliferous sediments overlying the Upper Coal Measures (Missourian series) of the Kansas-Nebraskan area, in which faunas succeed one another uninterruptedly from base to summit, as was first contended by Meek. The lower 400 feet (Neosho and Chase formations) con-

<sup>1</sup> Proc. U. S. Nat. Mus., Vol. XIV., 1891, p. 447.

stitute a distinct terrane, — often referred to as the Permo-Carboniferous, — the majority of its species being common to the Upper Coal Measures, and perhaps one-half of the species occurring in the succeeding 300 or 400 feet (Sumner stage of Cragin) being also common to them. But in the upper terrane, the so-called "Red Beds" or Cimarron series, which exhibit a thickness further southward of from 1000 to perhaps 2200 feet, no fossils have been found which are at all closely related to those of the Coal Measures, and writers are pretty generally agreed in correlating this series with the Upper Permian (Neo-Dyas) of Europe.

In the same way there appears to be good reason for believing that the lower part of the Big Blue series (Chase and Neosho strata) correspond to the Artinsk stage, which is the oldest Permian of Russia. Owing to the absence of Cephalopods, however, and general transitional character of the Neosho, no distinct line of separation between the Lower Permian and Carboniferous can be said to exist. The demarcation between the two systems is drawn by Frech<sup>1</sup> at the base of the Chase stage, and this limit for the Lower Permian is also accepted by Prosser,<sup>2</sup> who places the Neosho member at the summit of the Missourian. In Prosser's original description of these formations, however, the line of separation between the Upper Coal Measures and Permian was doubtfully drawn between the Cottonwood and Neosho formations, an arrangement in which a number of writers have concurred.

Regarding the transitional faunal characters, it is remarked by Keyes<sup>3</sup> that "the most noteworthy feature of the organic remains, viewed as a whole, is the gradual replacement of a purely marine type by a shore and brackish water phase, as the change from open sea to closed water conditions took place, and finally to those in which life could not exist. . . . In this region as in Russia, the gradual replacement of a brachiopodous fauna by a Permian lamellibranch fauna follows the local change of open to closed sea conditions. The Permian element of these forms was merely a shallow water facies of the more typical Carboniferous fauna."

In Nebraska the so-called Permo-Carboniferous (Chase and Neosho) strata form the northern continuation of the Kansas beds, and agree with them in all essential characters. The area is described by Knight<sup>4</sup>

<sup>1</sup> *Lethaea Palaeozoica*, Vol. II., 1899, p. 378.

<sup>2</sup> Revised Classification of the Upper Palaeozoic Formations of Kansas. *Journ. Geol.*, Vol. X., 1902, p. 711.

<sup>3</sup> *Journ. Geol.*, Vol. VII., 1899, p. 354, *et seq.*

<sup>4</sup> *Ibid.*, p. 360.

as "of flat-iron shape, with the broad end to the south resting upon the Kansas-Nebraska line. The northern limit is probably in the vicinity of Roca, Lancaster County. On the east the boundary has only been approximated, . . . but it is supposed that it extends from Roca south and east into Johnston County, thence southward through the western end of Pawnee County into Kansas. The western boundary, from Roca to Beatrice, is also buried beneath a very thick bed of loess, but from Beatrice southward it is traced with considerable accuracy." An understanding of the stratigraphic relations of the Upper Palaeozoic rocks in

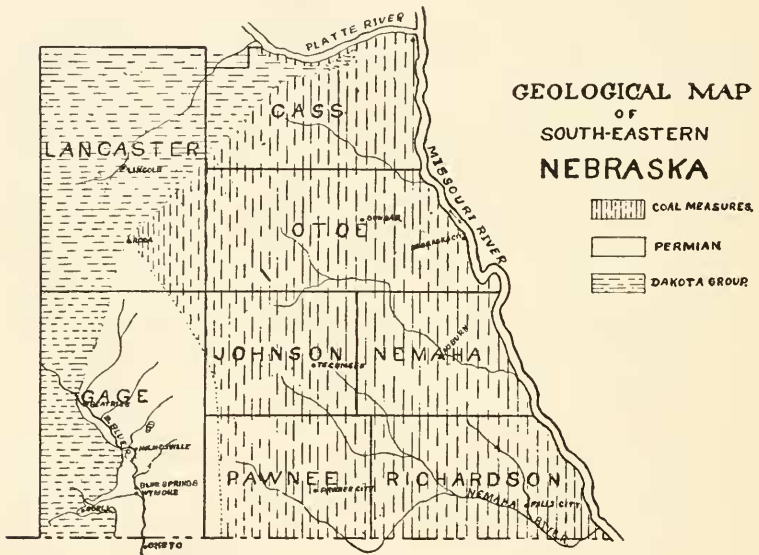


FIG. 1.

A Geological Map of Southeastern Nebraska (after Knight).

Nebraska will be facilitated by an inspection of the accompanying sketch-map and section, taken from Professor Knight's article, and of the following table of formations. The stratigraphy of the Kansas Coal Measures is described in the report of the University Geological Survey of Kansas, particularly in Volume III. by E. Haworth.

Nearly all of the fish-remains described in the present paper are from the Atchison shales, the principal localities being in Cass, Gage, Lancaster, Nemaha, and Sarpy counties. According to Dr. Barbour, the exposures at Cedar Creek, Louisville, South Bend, and Table Rock

may be referred to the summit of the Atchison, and those at Richfield and Springfield to its base. At Manhattan, Kansas, both the Atchison and Cottonwood are exposed.



FIG. 2.

A Geological Section of the Nebraska Permo-Carboniferous south and east from Beatrice to the Kansas line (after Knight).

SECTION OF THE UPPER PALAEOZOIC IN KANSAS AND NEBRASKA.

Permian System	{ Cimarron series { Big Blue series (" Permo-Carboniferous ")	{ Kiger shales { Salt Fork shales	
		{ Wellington shales { Marion limestone { Chase limestone { Neosho shales	{ Florence flint { Strong flint
Carboniferous System (Upper part only)	{ Missouriian series	{ Cottonwood limestone { Atchison shales { Forbes limestone { Platte shales { Plattsmouth limestone { Lawrence shales	

With these general remarks, we may now pass on to a consideration of the fish-fauna of the Kansas-Nebraska area in systematic order.

**ELASMOBRANCHII.**

**PLEURACANTHIDAE.**

**Pleuracanthus (Diplodus) compressus NEWBERRY.**

- 1856. *Diplodus compressus* J. S. Newberry, Proc. Acad. Nat. Sci. Philad., p. 99.
- 1866. *Diplodus compressus* Newberry and Worthen, Pal. Illinois, Vol. II., p. 60, Pl. IV., Fig. 2.
- 1870. *Diplodus compressus* O. St. John, Proc. Amer. Phil. Soc., Vol. XI., p. 432.

1872. *Diplodus compressus* O. St. John, Hayden's Final Rept. U. S. Geol. Surv. Nebraska, p. 240, Pl. IV., Fig. 19.  
 1873. *Diplodus compressus* J. S. Newberry, Rept. Geol. Surv. Ohio, Vol. I., Pt. II., p. 335.  
 1875. *Diplodus compressus* J. S. Newberry, *Op. cit.*, Vol. II., Pt. II., p. 45, Pl. LVIII., Fig. 2.

A single tooth of this species, from the Missourian of Rulo, Nebraska, is described and figured by St. John (1872), but no other examples have since been reported from this region. The species also occurs in the Upper Coal Measures of south-western Iowa, Indiana, and Ohio. Teeth of *D. platypternus* Cope are abundant in the Permian "Red Beds" of Texas.

## CLADODONTIDAE.

### *Cladodus occidentalis* LEIDY.

(Plate 2, Figs. 3, 8, 9.)

1859. *Cladodus occidentalis* J. Leidy, Proc. Acad. Nat. Sci. Philad., p. 3.  
 1866. *Cladodus mortifer* Newberry and Worthen, Pal. Illinois, Vol. II., p. 22, Pl. I., Fig. 5.  
 1870. *Cladodus mortifer* O. St. John, Proc. Amer. Phil. Soc., Vol. XI., p. 431.  
 1872. *Cladodus mortifer* O. St. John, Hayden's Final Rept. U. S. Geol. Surv. Nebraska, p. 239, Pl. III., Fig. 6, Pl. VI., Fig. 13.  
 1873. *Cladodus occidentalis* J. Leidy, Rept. U. S. Geol. Surv. Territ., Vol. I., p. 311, Pl. XVII., Figs. 4-6.  
 1897. *Cladodus mortifer* J. S. Newberry, Trans. N. Y. Acad. Sci., Vol. XVI., p. 285, Pl. XXII., Fig. 2.

The best description of this species is that given by St. John in 1872, who reports its occurrence in the Missourian of the Nebraska City section, Manhattan, Kansas, and south-western Iowa. Teeth of this species occur also in the Coal Measures of Illinois and Indiana.

A number of fragmentary teeth have been obtained by Professor Barbour from the Permo-Carboniferous of Roca, and Atchison shales (Missourian) of Table Rock, Nebraska, three of which are shown in the accompanying illustrations.

### *Cladodus knightianus* (COPE).

(Plate 2, Fig. 4.)

1891. *Styptobasis knightiana* E. D. Cope, Proc. U. S. Nat. Mus., Vol. XIV., p. 447, Pl. XXVIII., Fig. 2.

*Type.* — Imperfect crown; Museum of the State University of Nebraska.

The solitary example upon which Cope based his definition of this species was obtained by W. C. Knight from the "Florence Flint" (Chase formation)

of Blue Springs, Nebraska, and is shown of the natural size in Plate 2, Fig. 4. Inspection shows that Cope mistook the worn base of the crown for a truncate root, in allusion to which the name *Styptobasis* was given; and so far as may be judged from the form and ornamentation of the crown, it differs from the foregoing species merely in the fact of being somewhat more robust. The shallow median depression at the base of the crown on its outer face likewise occurs in *C. occidentalis*. Another Cladodont tooth, scarcely distinct from the latter species, is described by O. P. Hay under the name of *C. girtyi*, from the Coal Measures of Colorado.

*Formation and Locality.* — Permo-Carboniferous; Blue Springs, Nebraska.

### *Phoebodus knightianus*, sp. nov.

(Plate 4, Figs. 40, 40 a.)

*Type.* — Imperfect tooth; Museum of Comparative Zoölogy.

From the same locality as the preceding, Professor Knight secured some years ago one nearly perfect tooth and the root of a second specimen, which he cited as "*Diplodus*, sp. nov." in his faunal list of the Kansas and Nebraska Permo-Carboniferous.<sup>1</sup> Through the courtesy of their discoverer, these specimens have come into the possession of the Museum of Comparative Zoölogy, and form the basis of the following description. It is stated in a letter from Professor Knight that his attempt to remove some of the adherent matrix from the more perfect tooth resulted in some injury to the latter, and the broken parts were unfortunately not preserved. He had, however, observed that the three principal cones were all of the same height, and that the base was symmetrically developed. Accordingly, in the figures here given of the fractured specimen, its original outline is restored on Professor Knight's authority.

Teeth of moderate size, the median and two outer cones of equal height, and no intermediate denticles. All three cusps stout and erect, convex on both faces, with sharp lateral carinae, and a few delicate, slightly curved striae extending for a short distance upward from the base. Attached surface of root nearly plane, with a single pad-like prominence directly underneath the median cone; postero-superior surface with a rounded "button."

The root agrees in size and general form with that of *Diplodus platypternus* Cope, except that both the posterior button and antero-inferior prominence are of relatively smaller size. From *Phoebodus politus* Newb. and other Devonian species the present form is distinguished by the absence of intermediate denticles, a character in which it agrees with the Triassic *P. brodiei*. The type specimen is shown of four times the natural size in Plate 4, Figures 40 and 40 a, but in these illustrations the anterior boss on the lower surface of the root

<sup>1</sup> Journ. Geol., Vol. VII., 1899, pp. 366, 372, 374, 491.

is represented a little too conspicuously. In Figure 39 of the same plate is shown a tooth belonging to another species of *Phoebodus*. A good figure of *P. politus* Newb., from the Cleveland Shale of Ohio, may be found in the *Journal of Geology*, Vol. VII., 1899, p. 492.

*Formation and Locality.* — Permo-Carboniferous; Blue Springs, Nebraska.

## PETALODONTIDAE.

Fortunate discoveries of *Janassa* afford the means for a clear understanding of the dentition and form of body in the ray-like creatures belonging to this family. *Janassa* exhibits a ray-shaped trunk covered with smooth, rounded, quadrate granules, and large pectoral fins which extend forward to the head, the pelvic pair being separated from them by an interspace. There are no fin-spines, the mouth-cleft is very narrow, as in rays, and the tail is slender. There can be no doubt that forms like this, or like *Taniobatis*, *Copodus*, *Psammodus*, *Archaeobatis*, etc., were early approximations to the modern ray type, whether we consider them as genetically related to the latter or not.

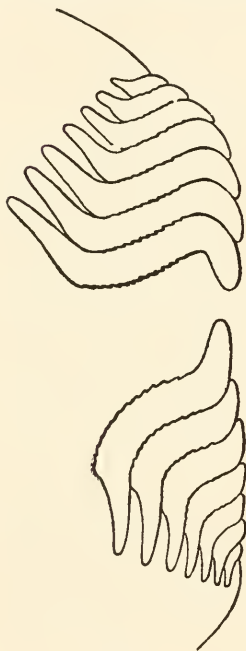


FIG. 3.

Diagram showing arrangement of upper and lower dentition in *Janassa bituminosa* Schloth. (Slightly modified after the restorations by Hancock and Howse, and O. Jaekel.)  $\times \frac{3}{4}$ .

The dentition of *Janassa*, as determined with entire accuracy by Hancock and Howse in *J. bituminosa*, is similar in both jaws, and consists of a median or symphyseal, and three pairs of lateral series, each having from four to seven teeth, the lateral series diminishing regularly in size from the center outwards. The lower dentition is more strongly arched and at the same time less extended from side to side than the upper, and the cutting-margins of the lower functional teeth bite inside those of the opposite jaw. The teeth of the outermost lateral series in the upper jaw slightly exceed those of the corresponding lower rows in width. The manner of succession is peculiar in that the oldest-formed teeth, after they have ceased to be functional, become piled upon one another in front of and away from the oral margin, thus affording firm support for the functional ones (*cf.* Text-fig. 3). The teeth of each series are closely wedged together and interlock with those of adjoining rows, the whole forming a very compact mass.

The arrangement of teeth in *Janassa* is well illustrated in the figures given



by Hancock and Howse over thirty years ago,<sup>1</sup> and more recently by Jaekel,<sup>2</sup> the latter author reaffirming the correctness of his predecessors' conclusions. According to these writers, the strongly reflected, scoop-like extremity of the crown served for a cutting-margin, and the pavement-like, rugose, or imbricated portion as a triturating surface. This interpretation appears plausible enough in the case of some species, but must not be supposed to be of universal application amongst Petalodonts, very different conditions having existed in certain other genera. Teeth of *Petalodus* and *Petalorhynchus* have been found in successional series, the crowns overlapping and more or less erect (*cf.* Text-fig. 4), but it is not known how many of such series constituted the complete dentition. In these genera, as in *Janassa*, the median series are larger than the rest and bilaterally symmetrical, those of the lateral series more or less oblique. It was long ago observed by Hancock and Howse<sup>3</sup> that *Petalodus* was provided with both symmetrical and oblique rows of teeth, and that examples had been "found lying in regular order, as if forming a portion of a vertical row." Consequently we must express ourselves as at variance with Jaekel's conjecture that the teeth of *Petalorhynchus* probably represent the symphyisial series of *Petalodus*, their disparity in size and discordant distribution clearly entitling them to recognition as distinct genera. There are also excellent reasons for dissenting from his proposed union of *Petalodus* and *Ctenoptychius*, and from his theoretical association of the fin-spines known as *Stichacanthus* and *Physonemus* (including *Xystracanthus* and *Batacanthus*), with *Polyrhizodus* and *Petalodus* respectively. Not only do the facts of distribution militate with this last assumption, but the absence of fin-spines in *Janassa* renders it extremely improbable that such defences were present in other members of the same family.

It is inferred by Hancock and Howse from the fineness of the cutting-edge in two species of *Janassa* that the food must have consisted of soft material. They state of *J. bituminosa* that "the scoop-like cutting-margin is certainly much used, for it is almost always greatly worn in a regular manner; only in one instance have we seen it a little broken. It would be an efficient instrument in cutting vegetable substances, and these might afterwards require the aid of the crushing-disk." The presence of a carbonaceous mass in the abdominal region of certain specimens also suggests to them herbivorous habits. Jaekel, on the other hand, in discussing the probable food of the Permian *J. bituminosa*,



FIG. 4.

*Petalorhynchus psittacinus* (McCoy). Lower Carboniferous; Armagh, Ireland. Naturally associated series of seven teeth. Outer face,  $\times \frac{1}{1}$ .

<sup>1</sup> Hancock, A., and Howse, R., On *Janassa bituminosa*, Schlotheim. Ann. Mag. Nat. Hist. (4), Vol. V., 1870, p. 47, Pl. II., III.

<sup>2</sup> Jaekel, O., Ueber die Organisation der Petalodonten. Zeitschr. deutsch. geol. Ges., Vol. LI., 1899, p. 258.

<sup>3</sup> *Loc. cit.*, p. 61.

argues from the worn condition of the triturating surface that the fare consisted of hard-shelled prey, such as Brachiopods and Pelecypods, and cites an example preserved in the Bergakademie in Berlin where a number of Productae are contained within the abdominal cavity. It is reasonable to suppose that the relative tenuity or thickness of the cutting-edge amongst different species of *Janassa* furnishes an approximate indication of their having subsisted on soft or hard shelled prey, as the case may be.

*Janassa maxima*, sp. nov.

(Plate 2, Fig. 21; Plate 3, Fig. 24.)

*Type.* — Imperfect crown; University of Nebraska.

Teeth extremely large and robust, with very high and strongly reflexed crown and thick cutting-margin. Posterior two-thirds of oral surface convex and covered with numerous prominent oblique plicae displaying indications of wear during life. Anterior face strongly convex, smooth, the posterior two-thirds elevated into two abrupt longitudinal ridges which are separated by a broad median longitudinal channel. Anterior face showing marks of contact with next oldest underlying tooth, the only indications of wear during life being directly along the cutting-margin.

Of this species only the unique tooth shown of the natural size in the accompanying illustrations is known at present. This is at least twice the size of the Permian *J. bituminosa* (Schloth.), the largest previously known species, which it approaches more closely than any others. In fact, the relations of this new species are altogether with those of Permian, rather than with those of Carboniferous age.

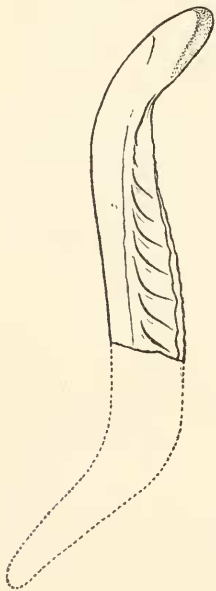


FIG. 5.

*Janassa maxima*, sp.  
nov. Profile,  $\times \frac{1}{2}$ .

The whole of the root and posterior portion of the crown are missing, and a portion of the cutting-edge of the crown has also been broken away. Even in its mutilated condition, however, the crown exhibits a total length of nearly 5 cm. Its lateral borders are straight, proving that the tooth was not deformed by interlocking with those of adjoining series. As to the position in the mouth occupied by this tooth, the marks of wear indicate very clearly that it belonged in one of the principal series to the left of the symphysial in the upper jaw. The tooth opposed to it in the lower jaw played inside its cutting-edge, and slightly to the left instead of squarely against it. The asymmetrically worn condition of the cutting-edge in

*J. bituminosa* is very distinctly shown in Hancock and Howse's figures,<sup>1</sup> and also in Jaekel's.<sup>2</sup> There can be little doubt that the action of the jaws upon one another was similar to that obtaining in modern Gymnodonts and Chimaeras. It has been stated in the definition of this species that the anterior face of the crown exhibits marks of contact with the next older tooth which it displaced. These markings are of two kinds. In the first place a raised line extending parallel with the cutting-edge at a distance of about a centimeter behind it (Pl. 3, Fig. 24) demarcates the area overlapped by the preceding tooth; in other words, it divides the exposed cutting-edge from the covered portion. Secondly, the longitudinal ridges on the anterior face display a number of parallel facettes caused by the impress of the oblique folds on the triturating surface of the next older tooth which this one displaced. Similar markings have been observed on the anterior face of teeth belonging to *J. bituminosa*, and this interpretation is given of them by Messrs. Hancock and Howse.<sup>3</sup> The thickness of the cutting-margin (*cf.* Text-fig. 5) and generally stout condition of the present specimen render it probable that the creature subsisted on hard-shelled prey.

*Formation and Locality.* — Atchison shales (Missourian); Richfield, Nebraska.

### *Janassa unguicula*, sp. nov.

(Plate 2, Fig. 13.)

*Type.* — Imperfect tooth; University of Nebraska.

Teeth delicate and of moderate size; crown much reflexed, regularly arched from side to side, and with a knife-edge trenchant margin. Outer coronal face smooth, posterior face entirely covered with fine longitudinal striae. Form of triturating surface and root unknown.



FIG. 6.

*Janassa unguicula*, sp. nov. Outer face of crown,  $\times \frac{1}{2}$ . A, Vertical section. B, Oral aspect, viewed from above,  $\times \frac{1}{2}$ .

This species is represented by a unique specimen from the Missourian of Cedar Creek, Nebraska, shown of the natural size in Plate 2, Fig. 13, and Text-fig. 6. Only the cutting portion of the crown is preserved, the crushing surface (if one was indeed present) and root having been broken away. The size

<sup>1</sup> Ann. Mag. Nat. Hist. (4), Vol. V., 1870, Pl. II., Fig. 2.

<sup>2</sup> Zeitschr. deutsch. geol. Ges., Vol. LI., 1899, Pl. XIV., Fig. 2.

<sup>3</sup> *Loc. cit.*, p. 55.

is approximately that of *J. clavata* from the British Carboniferous Limestone, the width being 1.4 cm., and the height 0.9 cm. The cutting-margin is compressed to a sharp edge, and the thickness at the base of the crown is only 2 mm. From the general symmetry of the crown, and shallow sinus in the middle of the cutting-edge, it is to be inferred that the tooth occupied a position in the symphyseal series. The area overlapped by the tooth immediately preceding on the anterior face of the crown is very plainly demarcated. The darker colored band along the cutting-margin appears to be due to fortuitous mineralization.

The present species does not appear to be at all closely related to other American or European forms, and only remotely resembles certain teeth described from the St. Louis and Chester formations under the names of *Tanaodus sculptus* and *T. polymorphus* St. J. and W. The general delicacy of the specimen is suggestive of *Peltodus unguiformis* N. and W., from the Coal Measures of Illinois, but the form and surface markings are different. *Tanaodus* and *Peltodus* are probably both synonyms of *Janassa*. Cope's original descriptions of *J. strigilina* and *J. gurleyana* have recently been republished with figures by E. C. Case, in the *Journal of Geology*, Vol. VIII., 1900.

*Formation and Locality.*—Atchison shales (Missourian); Cedar Creek, Nebraska.

#### FISSODUS ST. JOHN and WORTHEN.

The chief distinguishing character between this genus and *Janassa* is that the trenchant margin is cleft or divided into two or three broad acuminate points. The so-called *Cholodus*, comprising the single species *C. inaequalis*, was held by St. John and Worthen to be distinct from *Fissodus* in that the cutting-margin was eccentrically lobed. The circumstance that the imperfect specimens studied by these authors were unsymmetrically worn is attributable to their having occupied a position among the lateral series of the mouth in *Fissodus*.

#### *Fissodus inaequalis* (ST. JOHN and WORTHEN).

(Plate 2, Fig. 11; Plate 3, Fig. 26.)

1875. *Cholodus inaequalis* St. John and Worthen, Pal. Illinois, Vol. VI., p. 416, Pl. XIII., Figs. 4, 5.

There can be no question that the well-preserved crown shown in the accompanying illustrations is specifically identical with the fragmentary teeth from the Upper Coal Measures of Iowa and Illinois, described by St. John and Worthen as *Cholodus inaequalis*. The symmetrically formed outlines of the present specimen indicate its having pertained to the symphyseal series, and by the same token those figured by St. John and Worthen occupied a lateral position. The root has been broken away from the specimen in hand, but the imbricated belt corresponding to the triturating surface in *Janassa* is well

preserved, and exhibits four prominent, posteriorly curved folds which have become worn either by attrition during life, or by postmortem abrasion, or both.

Indications of at least one pair of rudimentary lobes appear along the lateral border half-way between the terminal apices and the plicated area. The cutting-margin is moderately thin, and below it for some distance on either face the dentine tubules have become exposed through atmospheric erosion. The marks of overlap by the tooth immediately preceding this are rather indistinctly shown. A shallow longitudinal depression occupies the middle portion of the anterior face opposite the imbricated area, a condition similar to that observed in *Janassa maxima*.

*Formation and Locality.* — Missourian; Peru and Louisville, Nebraska; Topeka, Kansas; also in Iowa, Illinois, and Missouri.

### **Fissodus dentatus, sp. nov.**

(Plate 2, Fig. 12.)

*Type.* — Detached crown; Museum of Comparative Zoölogy.

*Definition.* — Teeth of comparatively small size, oval in general outline, with faintly serrated lateral border and cutting-margin divided by a median cleft into two strong, acuminate cusps. Anterior face smooth, uniformly and strongly convex in a vertical direction, more gently arched from side to side. About one-half of the anterior face overlapped by the next older tooth in front.

A small, beautifully preserved crown from the Missourian of Topeka, Kansas, collected by the late S. A. Miller, and now belonging to the Museum of Comparative Zoölogy, is taken as the type of this species, which differs from other *Fissodus* teeth in having serrated lateral margins. This character is of interest inasmuch as it determines *Fissodus* to be intermediate in position between *Janassa* and *Ctenoptychius*. The general configuration of the crown resembles that of *F. tricuspoidatus*, but on the other hand it agrees with *F. bifidus* in possessing a deeply cleft, equilobed cutting-margin. There are three tolerably distinct serrations along the upper third of the lateral margin on either side, below which are several faint crimpings of the delicate edge. The posterior face is concealed by matrix, and the root has been broken away. The total height of the crown is a fraction over, and the extreme width a fraction under 7 mm.

*Formation and Locality.* — Missourian; Topeka, Kansas.

### **PETALODUS OWEN.**

The teeth of this genus have petal-shaped crowns which are much elongated from side to side, and shortened in the opposite direction. The cutting-margin is smooth or at most delicately crenulated, but not serrated, and the

base of the crown has several narrow imbricating folds of dentine descending lower on the posterior than on the anterior face. The root is relatively large in typical species, with a tumid and truncated lower extremity, and is longest and broadest in teeth belonging to the symphyisial series. The shortness of the root in some species has led to the establishment of such genera as "Antliodus" and "Chomatodus," which are best included under the same head as the more typical forms.

Although the teeth of *Petalodus* are scarcely distinct from those of *Ctenoptychius*, as already observed by Traquair,<sup>1</sup> practical reasons render it desirable to retain the former as a provisional genus, and besides, the uniformly entire condition of the cutting-margin in *Petalodus* seems to be a character of more than specific value. A serrated cutting-margin is simulated only amongst unequally worn teeth, usually belonging to the lateral series, in some species. In *Ctenoptychius* the teeth of both upper and lower jaws are distinctly serrated, in *Peripristis* only those of the upper jaw. The teeth of *Petalodus* are known to have been arranged in series closely similar to those of *Janassa*, the larger and symmetrically formed teeth occupying a symphyisial position, and the lateral series diminishing in size, besides becoming more oblique, on passing from the center. Jaekel's conjecture that the symphyisial series were of the form known as *Petalorhynchus* is clearly untenable.

### *Petalodus alleghaniensis* LEIDY.

(Plate 2, Figs. 17, 18; Plate 3, Fig. 27.)

1853. *Petalodus ohioensis* J. M. Safford, Amer. Journ. Sci. (2), Vol. XVI., p. 142.  
[Insufficiently defined.]
1856. *Sicarius extinctus* J. Leidy, Proc. Acad. Nat. Sci. Philad., Vol. VII., p. 414.  
[Insufficiently defined.]
1856. *Petalodus alleghaniensis* J. Leidy, Journ. Acad. Nat. Sci. Philad. (2), Vol. III., p. 161, Pl. XVI., Figs. 4-10.
1866. *Petalodus destructor* J. S. Newberry and Worthen, Pal. Illinois, Vol. II., p. 35, Pl. II., Figs. 1-3.
1870. *Petalodus destructor* O. H. St. John, Proc. Amer. Phil. Soc., Vol. XI., p. 433.
1872. *Petalodus destructor* O. H. St. John, Hayden's Final Rept. U. S. Geol. Surv., Nebraska, p. 241, Pl. III., Fig. 5.
1873. *Petalodus alleghaniensis* J. Leidy, Rept. U. S. Geol. Surv. Territ., Vol. I., p. 312, Pl. XVII., Fig. 3.
1875. *Petalodus alleghaniensis* J. S. Newberry, Rept. Geol. Surv. Ohio, Vol. II., p. 52, Pl. LVIII., Fig. 13.
1875. *Petalodus alleghaniensis* St. John and Worthen, Pal. Illinois, Vol. VI., p. 396.
1895. *Petalodus securiger* O. P. Hay, Journ. Geol., Vol. III., p. 561, Figs. 1, 2.
1896. *Petalodus alleghaniensis* C. R. Eastman, Journ. Geol., Vol. IV., p. 174.
1899. *Petalodus* sp. O. Jaekel, Zeitschr. deutsch. geol. Ges., Vol. LI., p. 287, Fig. 6 A.

<sup>1</sup> Geol. Mag. (3) Vol. V., 1888, p. 85.

A large series of this exclusively Upper Carboniferous species have come under the writer's observation, a study of which shows a wide range of variation to exist between the large, symmetrically formed, symphysial teeth, such as is represented in Pl. 2, Fig. 17, and the low-crowned, short-rooted, often quite asymmetrical teeth belonging to the outermost of the lateral series. The form of the root is even more variable than that of the crown, as one may satisfy himself by comparison of Figs. 17 and 18 of Plate 2, or the other figures of this species contained in the literature. Dr. O. P. Hay has commented on the fact that in Newberry and Worthen's figures of *P. destructor* the lateral angles of the crown are acutely terminated, and notes that in the specimen named by him *P. securiger* they are rounded off, at which point the enamel folds become flexed upward. This appears to be the normal condition manifested by all perfectly preserved teeth, but the root being extremely attenuated close to the lateral angles, the edges are rarely found entire. And it is perfectly evident from Newberry and Worthen's Figs. 1-3 that none of the lateral angles in their specimens have escaped injury.

The imbricated enamel folds at the base of the crown are sometimes distinctly raised on both faces, and usually appear smoother on the anterior than on the posterior face, as if from contact with adjacent older teeth of the same series. The extent to which the teeth of a single series overlapped one another seems to have been greater than in *Janassa*, and equals that in *Petalorhynchus*<sup>1</sup> and *Ctenoptychius*.<sup>2</sup> Marks of wear also seem to show that the upper and lower dentition interlocked by a comparatively small margin.

Besides the single tooth of this species described by St. John from the Missourian of Rock Bluff, Nebraska, numerous examples have been obtained by Professor Barbour from the same formation at Richfield and Table Rock, and from the Permo-Carboniferous of Roa, Nebraska.

*Formation and Locality.*—Coal Measures; Pennsylvania, Ohio, Illinois, Iowa, Nebraska, Arkansas. Permo-Carboniferous; Nebraska.

#### *Petalodus* (*Chomatodus*) *arcuatus* (St. John).

1870. *Chomatodus arcuatus* O. H. St. John, Proc. Amer. Phil. Soc., Vol. XI, p. 435.  
 1872. *Chomatodus arcuatus* O. H. St. John, Hayden's Final Rept. U. S. Geol. Surv. Nebraska, p. 243, Pl. VI., Fig. 14.  
 1875. *Chomatodus arcuatus* St. John and Worthen, Pal. Illinois, Vol. VI., Pl. X., Fig. 23.

Low-crowned teeth of the form commonly ascribed to *Chomatodus* (*pars*) in all probability represent the postero-lateral series of *Petalodus*, and it would seem that this genus possessed a larger number of transverse series than *Janassa*, as well as a more elongated mouth-cleft. The narrow, ray-like mouth-cleft in *Janassa* is regarded by Jaekel as evidence of specialization.

<sup>1</sup> Cf. J. W. Davis, On the fossil Fishes of the Carboniferous Limestone Series, Trans. Roy. Dublin Soc. (2), Vol. I., 1883, p. 426, Pl. LXI., Fig. 16.

<sup>2</sup> Cf. St. John and Worthen, Pal. Illinois, Vol. VI., 1875, Pl. XII., Fig. 9.

A single tooth of this species is described by St. John from the Missourian near Nebraska City, and another is figured by St. John and Worthen from a corresponding horizon in Adams County, Iowa. Professor Barbour has also obtained a solitary example from the Atchison shales of Peru, Nebraska.

*Formation and Locality.* — Missourian; Iowa and Nebraska.

### **Ctenoptychius occidentalis** (ST. JOHN and WORTHEN).

(Plate 2, Fig. 10.)

1875. *Ctenoptetalus occidentalis* St. John and Worthen, Pal. Illinois, Vol. VI., p. 401, Pl. XII., Fig. 14.

This species is founded on very delicate, gently arched teeth with relatively few (10-12) and obtuse coronal serrations, the broad basal band on the outer face being sharply set off from the exposed portion of the crown. The two examples known to the authors of this species were derived from the Lower Coal Measures in the vicinity of Fort Dodge, Iowa. The trivial title of *occidentalis* was bestowed by the same authors upon still another species of *Ctenoptychius*, which they placed in the now obsolete genus "Harpacodus." The form occurs in the St. Louis limestone of Illinois and Missouri, and so closely resembles *C. compactus* (St. J. and W.) from the Chester Group, that we have no hesitation in uniting it with that species. A single detached crown of *C. occidentalis*, somewhat weathered, was obtained by Professor Barbour from the Atchison shales of Richfield, Nebraska.

*Formation and Locality.* — Productive Coal Measures; Iowa. Missourian; Nebraska.

## PERIPRISTIDAE.

### PERIPRISTIS ST. JOHN.

Proc. Amer. Phil. Soc., Vol. XI., 1870, p. 434.

*Hoplodus* R. Etheridge, jun., Geol. Mag. (2), Vol. II., 1875, p. 243.

*Diodontopsodus* J. W. Davis, Brit. Assoc. Rept., 1881, p. 646.

*Pristodus* J. W. Davis (ex Agassiz MS.), Trans. Roy. Dublin Soc. (2), Vol. I., 1883, p. 519.

### **Peripristis semicircularis** (NEWBERRY and WORTHEN).

(Plate 2, Figs. 5-7; Plate 3, Fig. 25.)

1866. *Ctenoptychius semicircularis* Newberry and Worthen, Pal. Illinois, Vol. II., p. 72, Pl. IV., Fig. 18.

1870. *Peripristis semicircularis* O. H. St. John, Proc. Amer. Phil. Soc., Vol. XI., p. 434.



1872. *Peripristis semicircularis* O. H. St. John, Hayden's Final Rept. U. S. Geol. Surv. Nebraska, p. 242, Pl. III., Figs. 3, 4, Pl. IV., Fig. 20. •
1875. *Ctenoptychius semicircularis* J. S. Newberry, Rept. Geol. Surv. Ohio, Vol. II., p. 52, Pl. LVIII., Fig. 14.
1902. *Peripristis semicircularis* C. R. Eastman, Geol. Mag. (IV.), Vol. IX., p. 389, Text-fig. 1.

It is evident from marks of contact that the relations between the supposed upper and lower teeth of this species are identical with those known to obtain in *P. falcatus*, a specimen of the latter having been found which displays the



FIG. 7.

*Peripristis semicircularis* (N. & W.). Chester Group, Kentucky. Lower tooth, in profile and front view,  $\times \frac{1}{4}$ .

dental plates of both jaws in natural association. The tooth which may be provisionally referred to the lower jaw in all these forms is the one which fitted inside that of the opposite jaw when the mouth was closed, this condition having been ascertained to hold in the case of *Janassa*, and being true among sharks generally. The lower tooth of *P. semicircularis* differs from the upper



FIG. 8.

*Peripristis semicircularis* (N. & W.). Chester Group, Kentucky. Upper tooth, in profile and front view,  $\times \frac{1}{4}$ .

in having the serrations of the cutting-edge obsolete, or nearly so, and the basal border deflected downward in the median line in front, as shown in Text-figure 7. It also has a longer root than the upper tooth. The coronal margin of the latter is always strongly serrated in the unworn condition (Text-fig. 8), there being usually four denticulations on one side of the median line and five on the other. The coronal cavity of the upper tooth exhibits a deep pit in the median line at the junction of the horizontal and vertical portions of the posterior face, but there is no groove extending from it on either side as in *P. falcatus*. In one specimen, that shown in Plate 2, Fig. 7, the pit is de-

veloped into a perforation passing entirely through the horizontal portion of the crown, a condition which is sometimes observed in *P. falcatus*. The Yorkshire species known as *P. benniei* (Etheridge) differs from both *P. falcatus* and *P. semicircularis* in that the coronal margin of the upper tooth is not dentated but smooth, and rises into an acuminate apex in front.

The original of Plate 2, Fig. 5, possesses some pathologic interest, inasmuch as it became deformed during life, either as the result of injury or of irregularity in growth. It is an upper tooth shown here in left lateral aspect, and both root and crown on the side away from the observer are strongly indented. Fine parallel scratches resulting from the attrition of food, and preserved as distinctly as in a fresh individual, extend in the same direction over both the inner and outer coronal face on the uninjured side, and their obliquity to the vertical axis indicates that the tooth stood slantwise in the jaw, only about half the cutting-margin functioning against the lower tooth. Had its position been erect in the jaw, these markings would of course have been vertical, as in all normally formed teeth. The serrations of the cutting-margin have become almost effaced through wear. The triangular form of the root (as seen in profile) is natural, and the sublunate surface for its attachment to the crown is well shown in the original of Plate 2, Fig. 7. The latter tooth is detachable from the matrix, thus exposing a mold of the posterior face. Impressions in the matrix show that the cutting-margin was prominently serrated, as in the original of Fig. 6 of the same plate, the root of which has not been freed from the matrix. For comparison with the Nebraska specimens shown in Plate 2, an illustration is given in Plate 3, Fig. 25, and also in Text-figure 8, of a large upper tooth from the summit of the Chester limestone in Kentucky. The originals of this and also of the lower tooth shown in Text-figure 7 were found by Mr. E. O. Ulrich in such close proximity at the same outcrop near Montgomery Switch, Caldwell County, as to leave scarcely any doubt that they pertained to a single individual.

*Formation and Locality.*—Atchison shales (Missourian); Bellevue, Nebraska City and South Bend, Nebraska. Productive Coal Measures; Ohio and Indiana. Chester Group; Caldwell County, Kentucky.

## COCHLIODONTIDAE.

### PLATYXYSTRODUS HAY.

The name *Platyxystrodus* has been proposed by O. P. Hay as a substitute for the preoccupied title of *Xystrodus*, the latter having been employed by Plieninger two years prior to the application of the term in 1860 by Morris and Roberts.

**Platyxystrodus occidentalis** (ST. JOHN).

1870. *Xystrodus (?) occidentalis* O. H. St. John, Proc. Amer. Phil. Soc., Vol. XI, p. 436.  
 1872. *Xystrodus (?) occidentalis* O. H. St. John, Hayden's Final Rept. U. S. Geol. Surv. Nebraska, p. 244, Pl. IV., Fig. 18.

This species is founded upon a single imperfect tooth, doubtfully of this genus, from the Missourian of Aspinwall, Nebraska. The general form is suggestive of *Deltodus*, but the coronal surface is described by St. John as exhibiting the characteristic punctations of *Platyxystrodus*.

**Deltodus angularis** NEWBERRY and WORTHEN.

(Plate 2, Fig. 19.)

1866. *Deltodus angularis* Newberry and Worthen, Pal. Illinois, Vol. II., p. 97, Pl. IX., Fig. 1.  
 1870. *Deltodus (?) angularis* O. H. St. John, Proc. Amer. Phil. Soc., Vol. XI., p. 437.  
 1872. *Deltodus (?) angularis* O. H. St. John, Hayden's Final Rept. U. S. Geol. Surv. Nebraska, p. 244, Pl. VI., Fig. 18.  
 1883. *Orthopleurodus carbonarius* St. John and Worthen, Pal. Illinois, Vol. VII., p. 192, Pl. XIII., Fig. 7 (non Figs. 6, 8).

The forms cited in the above synonymy all plainly belong to the genus *Deltodus*, and hence we find ourselves unable to agree with St. John and Worthen in their proposed union of this species with *Sandalodus*, on the basis of three fortuitously associated teeth described by them in Volume VII. of the Illinois Palaeontology. A small posterior dental plate was obtained by St. John from the Missourian of Nebraska City, and the larger one shown in Plate 2, Fig. 19, is from the same horizon near Louisville, Nebraska.

*Formation and Locality.* — Missourian; Kansas, Nebraska, Iowa, and Missouri. Lower Coal Measures; Illinois and Indiana.

**Sandalodus carbonarius** NEWBERRY and WORTHEN.

1866. *Sandalodus carbonarius* Newberry and Worthen, Pal. Illinois, Vol. II., p. 104, Pl. X., Figs. 4, 5.  
 1883. *Orthopleurodus carbonarius* St. John and Worthen. *Op. cit.*, Vol. VII., p. 192, Pl. XIII., Figs. 6, 8.  
 1889. *Orthopleurodus carbonarius* J. P. Lesley, Rept. Geol. Surv. Penn., Vol. II., pp. 568, 920, Pl. 4.  
 1895. *Orthopleurodus carbonarius* J. P. Lesley, Summary Geol. Penn., Vol. III., Pl. LXXI.

Examples of this species determined by St. John and Worthen as "long posterior teeth of the upper jaw" are reported by these authors from the "Upper Coal Measure strata near Topeka, Kansas."

## STREBLODUS AGASSIZ.

Streblodus may be conveniently retained as a provisional genus in the sense intended for its employment by Agassiz. A different interpretation has been suggested by St. John and Worthen,<sup>1</sup> who distribute the dental plates referred to Streblodus amongst the genera Cochliodus, Deltoptychius, and Chitonodus, but confirmation of their views by direct evidence is lacking. The same may be said regarding their theoretical reconstruction of the dentition in Deltoptychius, and we agree with Woodward<sup>2</sup> and others in preferring to adopt the interpretation of M'Coy<sup>3</sup> as amended by Davis.<sup>4</sup>

*Streblodus angustus*, sp. nov.

(Plate 2, Fig. 20, Text-figure 9.)

*Type.* — Posterior dental plate; Museum Nebraska State University.

*Definition.* — Posterior dental plate narrow and elongate, obliquely truncated in front, outer margin broadly arched, and postero-lateral border forming an acute angle with the inner margin. Posterior tumid portion of coronal surface sharply separated by an abrupt elevation from the anterior portion, and exceeding the latter in extent. Anterior portion crossed by a narrow, angulated, and very oblique ridge, with a slight thickening of the antero-lateral margin.



FIG. 9.

*Streblodus angustus*,  
sp. nov. Posterior  
dental plate,  $\times \frac{1}{4}$ .

The posterior dental plate upon which this species is founded has a total length of 2 cm., and width in the middle portion of 7 mm., the form being quite narrow and antero-posteriorly elongated as compared with other species. It bears a rather remote resemblance to *S. obliquus* (St. J. and W.) from the St. Louis limestone of Missouri, but is more attenuated and lacks the prominent fold along the antero-lateral border.

*Formation and Locality.* — Atchison shales (Missourian); South Bend, and Cedar Creek, Nebraska.

*Helodus rugosus* NEWBERRY and WORTHEN.

(Plate 2, Fig. 14.)

1870. *Helodus rugosus* Newberry and Worthen, Pal. Illinois, Vol. IV., p. 359, Pl. II., Fig. 10.

A detached tooth obtained by Professor Barbour from the Missourian of Table Rock, Nebraska, exhibits all the characters described for this species,

<sup>1</sup> Pal. Illinois, Vol. VII., 1883, p. 92.

<sup>2</sup> Cat. Foss. Fishes Brit. Museum, Pt. i., 1889, p. 212.

<sup>3</sup> Brit. Palaeoz. Foss., 1855, p. 621.

<sup>4</sup> Trans. Roy. Dublin Soc. (2), Vol. I., 1883, p. 432.

except that the coronal surface is not roughened or vermiculated. The latter appearance may be perhaps attributed to varying conditions of wear and preservation, and is doubtfully of specific value.

### PHYSONEMUS AGASSIZ.

The mostly small, highly tuberculated Ichthyodorulites known as *Physonemus*, *Erismacanthus*, *Gampsacanthus*, *Dipriacanthus*, etc., interpreted as lateral head-spines, may be provisionally referred to the *Cochliodontidae*.

#### *Physonemus asper*, nom. nov.

1859. *Xystracanthus arcuatus* J. Leidy, Proc. Acad. Nat. Sci. Philad., p. 3.  
 1873. *Xystracanthus arcuatus* J. Leidy, Rept. U. S. Geol. Surv. Territ., Vol. I., p. 312, Pl. XVII., Fig. 25.  
 1875. *Xystracanthus arcuatus* St. John and Worthen, Pal. Illinois, Vol. VI., p. 457.

The type species of *Physonemus* having been named *P. arcuatus* by M'Coy in 1848, it becomes necessary to designate the type of Leidy's so-called "*Xystracanthus*" by a new specific title on removing it to *Physonemus*. The name *P. asper* is accordingly proposed for it in allusion to the coarsely tuberculated style of its ornamentation. Jaekel's theoretical association of spines of this character with the teeth of *Petalodus* and *Polyrhizodus*, and also with the dermal tubercles of *Petrodus*, has not been proved by any direct evidence, and militates with the facts of distribution.

*Formation and Locality.* — Missourian ; Leavenworth, Kansas.

### CESTRACIONTIDAE.

#### ORODUS AGASSIZ.

#### *Orodus intermedius*, sp. nov.

(Plate 4, Figs. 35, 36.)

*Type.* — Detached tooth ; Museum of Comparative Zoölogy.

Teeth of medium size, upwards of 3 cm. in length. Coronal contour gradually rising into a nearly smooth dome-shaped median eminence ; longitudinal crest low, slightly wavy, giving off several groups of branching transverse wrinkles extending on either side, and forming slight buttresses on the outer coronal margin ; base of crown faintly crenulated along the inner margin.

The unique tooth answering to the above description was obtained by the late Mr. Samuel A. Miller from the Upper Coal Measures on the opposite side

of the river from Leavenworth, Kansas, near Weston, in Platte County, Missouri. The name by which it may be designated has reference to the intermediate characters which it displays between *Orodus* and *Campodus*. The coronal surface is elevated into a median prominence, and is marked with the longitudinal and transverse ridges which are so conspicuous a feature of *Orodus*, but at the same time the outer coronal margin, which at the most is only faintly crenulated in other species of *Orodus*, is here differentiated after the manner of *Campodus*. It is obvious that the two genera are very closely related, but the characters by which they may be provisionally distinguished appear to warrant their separation, at least until such time as we shall have obtained a more perfect knowledge of the arrangement of the dentition in both forms.

*Formation and Locality.* — Missourian; Missouri River Valley.

## CAMPODUS DE KONINCK.

### *Campodus variabilis* (NEWBERRY and WORTHEN).

(Plate 1, Fig. 1; Plate 2, Figs. 15, 16.)

1870. *Lophodus variabilis* Newberry and Worthen, Pal. Illinois, Vol. IV., p. 361, Pl. IV., Figs. 4, 5, 11.  
 1875. *Agassizodus variabilis* St. John and Worthen, *Op. cit.* Vol. VI., p. 318, Pl. VIII., Figs. 1-22.  
 1883. *Agassizodus variabilis* M. Lohest, Ann. Soc. Geol. Belg., Vol. XI., p. 305, Text-figs. 1, 3.  
 1901. *Campodus variabilis* C. R. Eastman, Science, Vol. XIV., p. 795.  
 1902. *Campodus variabilis* C. R. Eastman, Geol. Mag. (4), Vol. IX., p. 148, Pl. VIII., Fig. 1.  
 1902. *Campodus variabilis* C. R. Eastman, Bull. Mus. Comp. Zool., Vol. XXXIX., p. 57, Pls. I II., Pl. IV., Fig. 1.

Detached teeth of this species are of not infrequent occurrence in the Missourian of Iowa, Kansas, and Nebraska, and in two or three instances a large part of the dentition has been found in natural association. The complete dentition of one jaw (presumably the lower) is known from a series of interesting specimens, the most important of which was first described by St. John and Worthen in Volume VI. of the Palaeontology of Illinois, and has been since re-investigated by Max Lohest and the present writer. The original of this magnificent specimen is now preserved in the private collection of Mr. Frank Springer, and casts made from it by St. John in 1874 are in existence in a number of museums. One of these plaster casts was utilized in the construction of the model shown in Plate 1, which represents the restored dentition, the symphyseal series in front being photographed from an actual specimen belonging to the Museum of Nebraska State University.

The nearly complete ramus of the lower jaw described by St. John and

Worthen exhibits upwards of 450 teeth disposed in about 18 transverse series, the smallest teeth occurring toward the extremities, and increasing gradually in size toward the middle of the ramus. The series are arranged after the same general pattern as in Cestracion, as is evident from a comparison of the two figures given in Plate 1, Fig. 2 being from a photograph of the lower jaw of *Cestracion francisci* Girard.

For a description of the two examples of the symphyssial series which are known, reference may be had to a previous number of the Museum Bulletin, Vol. XXXIX., No. 3, and it need only be restated here that each individual

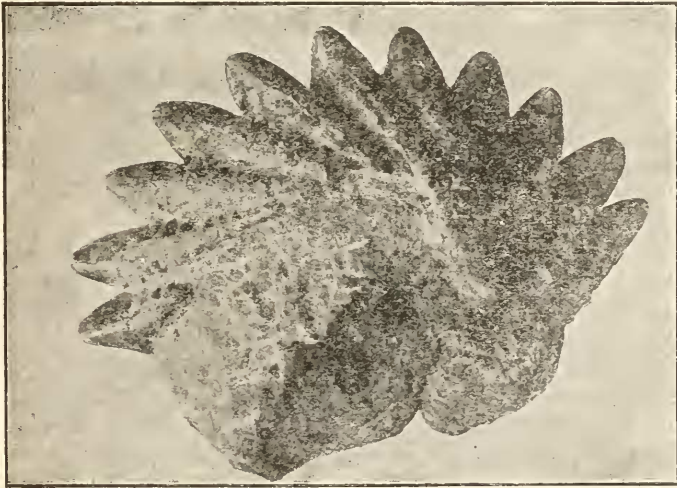


FIG. 10.

*Campodus variabilis* (N. & W.). Atchison shales, Cedar Creek, Nebraska. Lower symphyssial dentition,  $\times \frac{3}{4}$ .

of *Campodus* possessed at least three series of coalesced anterior or symphyssial teeth. As indicated by the marks of contact, there was a median arched azygous series in one jaw, presumably the lower, opposed to which (presumably) the upper were two corresponding series separated from each other by a slight interval and mutually interlocking with the former. Each of these series (Text-fig. 10) comprises from 11 to 13 enormously enlarged teeth which are fused into an arch corresponding to that of *Edestus* and *Campyloprion*, and to the thrice-coiled spiral of *Helicoprion*, all of which genera are to be regarded as highly specialized Cestraciont sharks.

This enlargement of the symphyssial series seems to be a hypertrophic character peculiar to Palaeozoic forms, first appearing in the Devonian *Protodus*,

and disappearing, so far as known, with *Helicoprion* in the Permian of Russia, India, and Japan. Occasionally the median azygous series of the lower jaw in *Cestracion philippi* is slightly enlarged, possibly through atavism. The ancient family of Cestraciontidae to which all these forms belong is remarkable not only for its astonishing longevity, almost unparalleled amongst fishes, but also for its prolific offshoots during Palaeozoic and Mesozoic times. The great groups of Coehliodonts, Orodonts, Acrodonts, and Hybodonts may all be considered as derivatives from the Cestracion stem, and it is probable that the modern ray-type is also descended from the same lineage.

The great variety in form manifested by the lateral teeth of *C. variabilis*, as implied by the specific title, has been well illustrated by St. John and Worthen. Some of the posterior series bear a strong resemblance to those of *Orodus*, but are distinguished by the buttressed condition of the coronal border and the less acuminate character of the series of lateral teeth. Only Jaekel has expressed an opinion that *Orodus* and *Campodus* are not generically distinct, and are intimately related to Psephodonts and Psanmodonts.<sup>1</sup> Examples of detached teeth of *C. variabilis* are shown in Plate 2, Figs. 13 and 14, the latter agreeing very closely with St. John and Worthen's Plate VIII., Fig. 4, of the sixth volume of the Illinois Palaeontology.

*Formation and Locality.* — Missourian; Kansas, Nebraska, Iowa, and Illinois.

### **Ctenacanthus amblyxiphias** COPE.

(Plate 2, Figs. 22, 23.)

1891. *Ctenacanthus amblyxiphias* E. D. Cope, Proc. U. S. Nat. Museum, Vol. XIV., p. 449, Pl. XXVIII., Fig. 3.

This species was originally described from the Permian of Texas, and does not appear to have been recognized up to the present time outside of the typical locality. The two fragmentary spines obtained by Professor Barbour are from the Missourian of South Bend and Louisville, respectively, in Nebraska. This form has a more angular cross-section than most of the Mississippian species of *Ctenacanthus*.

## **DIPNOI.**

### **CTENODONTIDAE.**

#### **Sagenodus copeanus** WILLISTON.

1899. *Sagenodus copeanus* S. W. Williston, Kansas Univ. Quart., Vol. VIII., p. 178, Pl. XXXV.-XXXVII.

This species is known by the upper dentition and a number of associated bones from the Missourian of Brown County, Kansas.

<sup>1</sup> Zeitschr. deutsch. geol. Ges., Vol. LI., 1899, p. 296.



## CROSSOPTERYGII.

## OSTEOLEPIDAE.

*Megalichthys macropomus* Cope.

1902. *Megalichthys macropomus* E. D. Cope, Proc. Amer. Phil. Soc., Vol. XXX., p. 226, Pl. VIII.

It is stated in the original description that this species is "established on the greater part of an individual from the Carbonic system of Kansas," then contained in the private collection of R. D. Lacoë. Fragments of another individual from the Leavenworth Coal near Lansing, Kansas, were obtained by Mr. O. H. St. John a number of years ago, and are now preserved in the Museum of Comparative Zoölogy. Two other species of *Megalichthys* have been described by Cope from the Permian of Texas.

## LIST OF FOSSIL FISHES OCCURRING IN THE UPPER CARBONIFEROUS OF KANSAS AND NEBRASKA.

## ELASMOBRANCHII.

- |   |   |
|---|---|
| 1. <i>Pleuracanthus (Diplodus) compressus</i> Newb. | 11. <i>Ctenoptychius occidentalis</i> St. J. and W. |
| 2. <i>Cladodus occidentalis</i> Leidy.              | 12. <i>Peripristis semicircularis</i> (N. and W.).  |
| 3. " <i>knightianus</i> (Cope).                     | 13. <i>Platyxystrodus occidentalis</i> (St. John).  |
| 4. <i>Phoebodus knightianus</i> Eastman.            | 14. <i>Deltodus angularis</i> N. and W.             |
| 5. <i>Janassa maxima</i> Eastman.                   | 15. <i>Sandalodus carbonarius</i> N. and W.         |
| 6. " <i>unguicula</i> Eastman.                      | 16. <i>Streblodus angustus</i> Eastman.             |
| 7. <i>Fissodus dentatus</i> Eastman.                | 17. <i>Ielodus rugosus</i> N. and W.                |
| 8. " <i>inaequalis</i> (St. J. and W.).             | 18. <i>Physonemus asper</i> Eastman.                |
| 9. <i>Petalodus alleghaniensis</i> Leidy.           | 19. <i>Orodus intermedius</i> Eastman.              |
| 10. <i>P. (Chomatodus) arcuatus</i> (St. John).     | 20. <i>Campodus variabilis</i> (N. and W.).         |
|   | 21. <i>Ctenacanthus amblyxiphias</i> Cope.          |

## DIPNOI.

22. *Sagenodus copeanus* Williston.

## CROSSOPTERYGII.

23. *Megalichthys macropomus* Cope.

## II. THE CARBONIFEROUS FISH-FAUNA OF MAZON CREEK, ILLINOIS.

Of the thousands of fossiliferous ironstone nodules of Coal Measure age, occurring at Mazon Creek, near Morris, in Grundy County, Illinois, only a small percentage yield indications of vertebrate remains, and these consist principally of detached fish-scales. Occasionally, however, complete individuals of fossil fishes, and in still fewer instances, Amphibian skeletons have been brought to light, but all told the number of even tolerably perfect specimens preserved in different museums is very insignificant. Probably the two finest series of Mazon Creek nodules ever brought together are the Lacoë collection, belonging to the United States National Museum at Washington, and the S. S. Strong collection, purchased by the late Prof. O. C. Marsh for the Yale Museum. Shortly before the decease of Professor Marsh, nearly all of the fossil fishes in the Strong collection were placed by that gentleman in the hands of the writer for investigation; and more recently some additional material has been loaned for the same purpose by Prof. C. E. Beecher, to whom grateful acknowledgments are hereby rendered.

Mazon Creek fish-scales have been exhaustively studied by E. D. Cope<sup>1</sup> and O. P. Hay,<sup>2</sup> and the latter has also described a nearly perfect example of a Palaeoniscid fish, named by him *Elonichthys hypsilepis*. Other Palaeoniscids and Platysomids have been described by Cope,<sup>3</sup> Newberry and Worthen,<sup>4</sup> and the present writer,<sup>5</sup> and the latter has also published descriptions of one Coclacanth and two Acanthodian species.<sup>6</sup> These citations complete the literature references on Mazon Creek fishes. In the following paragraphs a few new species are described, and the structure of certain Ganoids is examined more in detail than has been done heretofore.

### DIPNOI.

#### CTENODONTIDAE.

##### *Sagenodus cristatus*, sp. nov.

(Plate 3; Fig. 30.)

*Type*. — Palatine dental plate; Yale Museum.

Upper dental plate relatively short and broad, attaining a length of about 5 cm. and a maximum breadth of 3.5 cm. Outer margin nearly straight; coronal

<sup>1</sup> Proc. Amer. Phil. Soc., Vol. XXXVI., 1897, pp. 71-82.

<sup>2</sup> *Ibid.*, Vol. XXXIX., 1900, pp. 96-120.

<sup>3</sup> Proc. U. S. Nat. Museum, Vol. XIV., 1891, p. 462.

<sup>4</sup> Pal. Illinois, Vol. II., 1866, and Vol. IV., 1870.

<sup>5</sup> Journ. Geol. Vol. X., 1902, p. 450.

<sup>6</sup> Bull. Mus. Comp. Zool., Vol. XXXIX., 1902, pp. 93-94.

surface slightly concave, with at least seven prominent, rather broad and coarsely tuberculated ridges, the tubercles gradually decreasing in size from the abrupt outer towards the narrow inner margin.

This species is represented by a unique upper dental plate belonging to the Yale Museum, which is readily distinguished from other species by its abbreviate form and nearly straight parallel ridges. The tuberculations of the latter are coarser and less acuminate than in *S. vabasensis* Cope,<sup>1</sup> and the ridges resemble some species of *Ctenodus* in their non-radiating character. A narrow and elongate cranial plate, having the dimensions of 5 by 10 cm., and belonging to the same collection, may perhaps be correlated with this species. All other Dipnoan remains from the Mazon Creek locality are founded on detached scales.

*Formation and Locality.* — Coal Measures; Mazon Creek, Illinois.

## CROSSOPTERYGII.

### COELACANTHIDAE.

#### COELACANTHUS AGASSIZ.

J. S. Newberry<sup>2</sup> records having received from Mazon Creek "a single specimen each of *Eurylepis* and *Coelacanthus*, probably not distinct from those found at Linton," Ohio. No examples of the former genus have come under the writer's observation, but ornamented scales and head-plates referable to *Coelacanthus* sometimes occur in Mazon Creek nodules, and very rarely there are found complete fishes of small size, evidently quite distinct from those occurring elsewhere. In most specimens the posterior dorsal, anal, and pectoral fins are wanting, and one might be led to suppose at first that the second dorsal had become lost through specialization. A single example preserved in the Museum of Comparative Zoölogy shows it very distinctly, however, and the absence of this and the anal fin in other examples is therefore attributable to faulty preservation.

#### *Coelacanthus exiguus* EASTMAN.

(Plate 5, Fig. 48.)

1902. *Coelacanthus exiguus* C. R. Eastman, Journ. Geol. Vol. X., p. 538, Text-fig. 3.

*Type.* — Complete individual; Yale Museum.

A small species, attaining a maximum length of about 4.5 cm. Trunk narrow and elongated, the head occupying about one-fourth of the total length. First dorsal consisting of relatively few stout rays, and situated slightly in

<sup>1</sup> Journ. Geol. Vol. VIII., 1900, p. 704, Pl. 1, Fig. 7.

<sup>2</sup> Mon. U. S. Geol. Surv., Vol. XVI., 1889, p. 215.

advance of the pelvic pair; second dorsal midway between the anterior dorsal and principal caudal; the latter comprising nine stout rays above and below. Scale structure and ornamentation of head-bones not observed.

This species is represented by ten specimens in the Yale and one in the Harvard Museum, most of them being only about 3 cm. long, and very deficient in preservation. They agree in having a narrow, gradually tapering body, which terminates in an equilobate caudal fin, with indications that the axis was prolonged into a supplementary caudal. The anterior dorsal and caudal, owing to their firmer attachment, are preserved in nearly all specimens, but the remaining fins have in most cases become lost. The first dorsal has usually seven or eight stout rays, and is situated near the middle of the trunk. Ten long, hollow rays are to be counted in the single specimen displaying the posterior dorsal, and nine above and below in the symmetrical caudal. The neural and haemal spines are very long in the abdominal and caudal regions. The ossifications of the axial skeleton are continued nearly to the termination of the principal caudal. The squamation must have been exceedingly delicate, as no indications of scales are to be observed in any of the specimens, nor do any of them have the cranial elements satisfactorily preserved.

*Formation and Locality.* — Coal Measures; Mazon Creek, Illinois.

## ACTINOPTERYGII.

### PALAEONISCIDAE.

#### ELONICHTHYS GIEBEL.

Two closely related species are already known from Mazon Creek, *E. peltigerus* Newberry, and *E. hypsilepis* Hay. A study of the type specimen of Newberry and Worthen's so-called "*Amblypterus macropterus*," now preserved in the Yale Museum, leaves no doubt that this is only a mutilated individual of *E. peltigerus*. The type of *Rhadinichthys gracilis* (Newberry and Worthen) is also preserved in the Yale Museum.

#### *Elonichthys perpennatus* EASTMAN.

(Plate 5, Fig. 49.)

1902. *Elonichthys perpennatus* C. R. Eastman, Journ. Geol., Vol. X., p. 539, Text-fig. 4.

*Type.* — Complete individual; Museum of Comparative Zoölogy.

A very small species, having a total length of about 2.5 cm. of which the head occupies a little less than one fourth. Fins extremely well developed, the pectorals unusually long, and anal much extended; fulcra minute. Scales relatively small, obliquely striated; dorsal ridge-scales enlarged.

The solitary known and probably immature example of this species is shown of twice the natural size in Plate 5, Fig. 49. The head is poorly preserved, and the extremities of nearly all the fins are either broken away or obscured by matrix. Nevertheless sufficient characters remain for the recognition of this as a distinct species of *Elonichthys*, its chief peculiarity consisting in the remarkable development of all the fins. The pectorals are fully one fourth as long as the entire body, and the anal has a more extended base-line than in any other species of the genus. The dorsal appears to have been high and acuminate, but is largely concealed by matrix. The caudal is also unfavorably exposed, and flexed out parallel with the main axis, but it is plain that the upper lobe was much prolonged, and covered with very large, striated ridge-scales. The dorsal fin-rays appear to have been widely jointed; the articulations of the other fins are not clearly discernible. The dermal rays of the anal and lower lobe of the caudal are directly supported by the enlarged haemal spines, which are firmly united with their arches. The squamation is nowhere well preserved, but is best indicated in the anterior part of the trunk. The cranial structure does not admit of particular description.

### *Elonichthys disjunctus*, sp. nov.

(Plate 3, Fig. 31.)

*Type*. — Distorted individual; Yale Museum.

A species of about the same size as *E. peltigerus* and *E. hypsilepis*, and resembling them in general form and ornamentation, but differing in the position of the anal and structure of the paired fins. The latter are relatively shorter in the present species, and have fewer rays. The dorsal and anal are of about equal size, triangular and acuminate, and each with 25 or more rays. The anal is inserted opposite the middle of the dorsal, and its base-line terminates at a distance in advance of the caudal at least as great as the depth of the caudal pedicle. Caudal fin deeply forked and very finely divided; fulcra minute.

Several examples of this species are preserved in the Yale Museum, the smallest having a length of only 2.5 cm., and the largest upwards of 11 cm. While exhibiting the same proportions as *E. peltigerus* and *E. hypsilepis*, it differs in the less remote position of the anal fin. One specimen in the collection shows very perfectly the two series of piercing teeth, and about 14 branchiostegal rays. The original of Plate 3, Figure 31, which is selected as the type, has the body flexed in such wise as to present the ventral aspect of the head and greater portion of the trunk, while the region behind the anal fin is seen from the right-hand side. The caudal is very well shown; the anal, on the other hand, is somewhat distorted, and the dorsal and paired fins are wanting.

*Formation and Locality*. — Coal Measures; Mazon Creek, Illinois.

## PLATYSOMATIDAE.

Three unique specimens from the Mazon Creek locality, all more or less imperfectly figured and described, have been referred to as many species of *Platysomus*, and a fourth species has been described by Cope (*P. palmaris*) from the Permian of the southern part of Indian Territory. The characters of the so-called *P. orbicularis* Newberry and Worthen have never been defined, and the type specimen is here regarded as pertaining to *Cheirodus*.

*Platysomus circularis* NEWBERRY and WORTHEN.

(Plate 5, Fig. 51.)

1870. *Platysomus circularis* Newberry and Worthen, Pal. Illinois, Vol. IV., p. 347, Pl. IV., Fig. 2.

*Type*. — Complete fish ; Illinois State University, Urbana.

A very small species, attaining a maximum length of about 4 cm. Outline of body elliptical, greatest depth of trunk exceeding its length from the pectoral arch to the base of the caudal fin, and more than twice as long as the head with opercular apparatus ; dorsal margin gibbously rounded from the occiput to the narrow caudal pedicle, ventral margin regularly rounded. Dorsal and anal fins arising considerably behind the middle of the back, relatively high, and extending close to the origin of the caudal fin. Scales finely striated, the striae being parallel, even, and regular, vertical on those situated nearest to the ventral margin in advance of the anal fin, but oblique on the remaining longitudinal rows.

In the original figure of this species, the squamation is very distinctly shown, and the scales are described as being "oblong in outline, smooth, those on the sides three to six times as high as long." An examination of the type, however, kindly permitted by Prof. C. W. Rolfe, reveals the fact that the scales are very inaccurately drawn, and that their striated condition was overlooked by the authors. Several examples, clearly belonging to this species, are preserved in the Yale Museum, one of which has been selected for illustration in the accompanying plates, and the definition of the species has been amended in conformity with characters displayed by the additional material. The dorsal and anal fins are stated by Newberry and Worthen as consisting of forty and thirty dermal rays, respectively, but it is probable that even more than this number were present.

*Formation and Locality*. — Coal Measures ; Mazon Creek, Illinois.

## CHEIRODUS M'COY.

*Cheirodus orbicularis* (NEWBERRY and WORTHEN).

(Plate 5, Fig. 52.)

1870. *Platysomus orbicularis* Newberry and Worthen, Pal. Illinois, Vol. IV., Pl. III., Fig. I. (No description.)

A number of specimens in the Yale Museum agree with the figure published by Newberry and Worthen in having an orbicular body with scales arranged in very narrow vertical bands. The identity of these specimens with the type of *Platysomus orbicularis* is further confirmed by the fact that one of them is so labelled in Newberry's handwriting. The unsatisfactory illustration of this species induces a suspicion that the type was very imperfectly preserved, in which case it is not to be wondered that the authors failed to observe the dorsal and ventral peaks exhibited by other specimens. A study of all available material enables me to give the following amended definition of this species.

A small species, attaining a maximum length of about 4.5 cm. Trunk deep, orbicular in outline, the dorsal margin elevated into a prominent peak at about its middle point, and the ventral margin angulated to a somewhat lesser extent at a point about midway between the branchial apparatus and the narrow caudal pedicle. Facial contour of head steep, cranial plates granulated and striated; the head with opercular apparatus contained about two and one-half times in the total length to the base of the caudal fin. Dorsal and anal fins arising at a considerable distance behind the marginal peaks, and extending close to the origin of the caudal fin; the latter nearly equilobate, its upper lobe with well-developed fulera, and its width at distal extremity equaling about one third the maximum depth of trunk. Dorsal fin with fifty or more rays, caudal and anal each with a somewhat lesser number. (Paired fins not observed.)

Scales ornamented externally with faint longitudinal striae and usually one longitudinal ridge situated near the anterior border of each scale; attached surface coarsely striated, the striae being nearly vertical on the deeper flank-scales, but oblique on those situated dorsally and ventrally and in the caudal region. Scales of the anterior part of the trunk arranged in nearly vertical narrow bands, those toward the tail showing a slight downward and backward obliquity, and those at the base of anal fin reflexed forwards toward the ventral margin.

*Formation and Locality.* — Coal Measures; Mazon Creek, Illinois.

## LIST OF CARBONIFEROUS FISHES OCCURRING AT MAZON GREEK, ILLINOIS.

## ELASMOBRANCHII.

1. *Pleuracanthus (Diplodus) compressus* Newb. (Occurs also at Linton, Ohio, and in Indiana.)
2. " " *latus* Newb. (Occurs also at Linton, Ohio, and in Indiana.)
3. " " *lucasi* Hay.
4. *Acanthodes beecheri* Eastm.
5. " *marshi* Eastm.
6. *Campodus scitulus* (St. J. and W.).

## DIPNOI.

7. *Ctenodus* sp. indes.
8. *Sagenodus cristatus* Eastm.
9. " *foliatus* Cope.<sup>1</sup>
10. " *lacovianus* Cope.<sup>1</sup>
11. " *occidentalis* (Newb. and W.)<sup>1</sup> (Occurs also at Linton, Ohio.)
12. " *quadratus* (Newb.)<sup>1</sup> (Occurs also at Linton, Ohio.)
13. " *quincunciatus* Cope.<sup>1</sup>
14. " *reticulatus* (Newb. and W.)<sup>1</sup>
15. " *textilis* Hay.<sup>1</sup>

## CROSSOPTERYGII.

16. *Rhizodopsis (?) mazonius* Hay.<sup>1</sup>
17. *Coelacanthus exiguus* Eastm.
18. " *robustus* Newb.<sup>1</sup> (Occurs also at Linton, Ohio.)

## ACTINOPTERYGII.

19. *Eurylepis*, sp. indet. (*vide* J. S. Newberry).
20. *Rhadinichthys gracilis* (Newb. and W.).
21. *Elonichthys disjunctus* Eastm.
22. " *hypsilepis* Hay.
23. " *peltigerus* Newb.<sup>2</sup> (Occurs also at Linton, Ohio).
24. " *perpennatus* Eastm.
25. *Platysomus circularis* Newb. and W.
26. " *lacovianus* Cope.
27. *Cheirodus orbicularis* (Newb. and W.).

<sup>1</sup> Founded on scales.<sup>2</sup> Including also the so-called "*Amblypterus macropterus*" Newb. and W.



### III. SPECIES OF FOSSIL FISHES FROM THE MISSISSIPPIAN SERIES.

Under this head descriptions are given of several new species from the Kinderhook and Keokuk limestones of the Mississippi Valley, and the structure and systematic relations of certain others are considered concerning which a difference of opinion amongst authors has existed. For an opportunity to examine some of the type specimens described in the Palaeontology of Illinois the writer is indebted to the courtesy of Prof. C. W. Rolfe, of the State University at Urbana, and to Mr. C. H. Crantz, Curator of the State Museum at Springfield, Illinois.

The following table shows the commonly accepted subdivisions of the Mississippian series for this region:—

#### SECTION OF THE LOWER CARBONIFEROUS.

Mississippian Series.	{	Genevieve Group or Stage.	{	Chester limestone and shales (including the "Kaskaskia limestone").
				St. Louis limestone.
				Warsaw limestone (in part).
		Angusta (Osage) Group or Stage.	{	Keokuk limestone.
				Burlington limestone.
		Kinderhook Group or Stage.	{	Chouteau limestone.
				Hannibal shales.
				Louisiana limestone.

### ELASMOBRANCHII.

#### PLEURACANTHIDAE.

##### PHOEBODUS ST. JOHN and WORTHEN.

Of this genus three species are represented in the Devonian of this country, two in the Mississippian series, and one in the Permo-Carboniferous, including those described in the present paper. It is probable, however, that at least two forms ascribed by Newberry and Worthen to the "genus" *Diplodus*, namely, *D. incurvus* and *D. duplicatus*, should be referred to *Phoebodus* as commonly understood.

**Phoebodus dens-neptuni**, sp. nov.

(Plate 4, Fig. 39.)

*Type*. — Detached tooth; Museum of Comparative Zoölogy.

Teeth of moderate size, with three principal cones less than one cm. in height. Median cone erect, gradually tapering, lateral cones of unequal height, gently curved outward toward the apex; all three delicately striated, subcircular in cross-section, the median broader than the others.

This species is founded upon a unique tooth from the Keokuk limestone of Iowa, which seems to be intermediate in character between the so-called *Dip-lodus incurvus* and *D. duplicatus* of Newberry and Worthen accompanying it in the same horizon. From the former it is distinguished by its more slender form and striated cones, and from the latter by its possession of three principal cones instead of four, as in that species. The nature of the base is not determinable from the solitary example that is known of the present species.

*Formation and Locality*. — Keokuk limestone; Keokuk, Iowa.

## COCHLIODONTIDAE.

A deal of confusion exists regarding the nomenclature of certain species of *Sandalodus*, *Deltodus*, and *Deltoptychius* occurring in the Carboniferous rocks of the Mississippi Valley, a state of affairs which is attributable to the imperfect preservation of the greater number of their remains. A study of a large collection of *Cochliodont* teeth belonging to the Museum of Comparative Zoölogy and the United States National Museum has suggested the following synonymy in the case of several disputed species.

## SANDALODUS NEWBERRY and WORTHEN.

*Sandalodus laevis-simus* NEWBERRY and WORTHEN.

(Text-figure 11.)

1866. *Sandalodus laevis-simus* Newberry and Worthen, Pal. Illinois, Vol. II., p. 104, Pl. X., Figs. 6-8.
1866. *Sandalodus grandis* Newberry and Worthen, *Ibid.*, p. 105, Pl. X., Fig. 9.
1866. *Deltodus grandis* Newberry and Worthen, *Ibid.*, p. 101, Pl. IX., Fig. 9.
1866. *Cochliodus ? crassus* Newberry and Worthen, *Ibid.*, p. 91, Pl. VIII., Fig. 2.
1866. *Psammodus ? semicylindricus* Newberry and Worthen, *Ibid.*, p. 109, Pl. XI., Fig. 4.
1866. *Psammodus ? rhomboideus* Newberry and Worthen, *Ibid.*, p. 110, Pl. XI., Fig. 6.
- (?) 1879. *Deltodus grandis* J. S. Newberry, Ann. Rept. Geol. Surv. Indiana, 1876-78, p. 344

1883. *Sandalodus laevisissimus* St. John and Worthen, Pal. Illinois, Vol. VII., p. 186, Pl. XII., Figs. 8, 9 (and 5?).
1897. *Deltodus grandis* J. S. Newberry, Trans. N. Y. Acad. Sci., Vol. XVI., p. 297.
1900. *Sandalodus laevisissimus* C. R. Eastman, Amer. Nat., Vol. XXXIV., p. 581, Fig. 1.
1902. *Sandalodus laevisissimus* O. H. St. John, Amer. Nat., Vol. XXXVI., p. 659.

This species is very abundant in the Keokuk limestone of Iowa, Illinois, and Missouri, numerous perfect examples being known of both the posterior and anterior dental plates of upper and lower jaws. Most of the posterior dental plates have suffered the loss of the initial coiled portion, which is remarkable for being wound upon itself one and one-half times before expanding into the functional grinding surface characterizing the adult, as shown in the adjoining text-figure. The upper posterior dental plate resembles in a general way that of *S. morrisii* Davis, and is much less plicated than the lower. There can be no doubt as to the correctness of St. John and Worthen's conclusion that the type of *Deltodus grandis* Newb. and Worth. is identical with this species, hence we are unable to agree with the views expressed on this subject in the posthumous paper of Newberry.<sup>1</sup>

Dr. O. P. Hay is evidently mistaken in his remark that no type of the genus *Sandalodus* has been specified,<sup>2</sup> for *S. laevisissimus* is expressly designated as such by St. John and Worthen in their general observations on teeth of this form.<sup>3</sup> Dr. Hay is also in error, we believe, when he discards the specific title of *S. laevisissimus* in favor of *S. crassus*. But possibly this may be due to an oversight on his part, since the original description of *S. laevisissimus* with its accompanying illustrations—that which heads the list in the above synonymy—is omitted by him in his citations of the literature references.<sup>4</sup>



FIG. 11.

*Sandalodus laevisissimus* N. and W. Keokuk limestone, Keokuk, Iowa. Posterior dental plate of left mandibular ramus,  $\times \frac{2}{3}$ .

<sup>1</sup> Trans. N. Y. Acad. Sci., Vol. XVI., 897, p. 297.

<sup>2</sup> Bibliography and Catalogue of the Fossil Vertebrata of North America. Bull. U. S. Geol. Surv., No. 179 (1902), p. 288.

<sup>3</sup> Pal. Illinois, Vol. VII. (1883), p. 184.

<sup>4</sup> *Loc. cit.*, p. 289.

**Sandalodus complanatus** (NEWBERRY and WORTHEN).

1866. *Deltodus complanatus* Newberry and Worthen, Pal. Illinois, Vol. II., p. 98, Pl. IX., Fig. 4.  
 1866. *Trigonodus major* Newberry and Worthen, *Ibid.*, p. 112, Pl. XI., Figs. 3, 9.  
 1870. *Deltodus complanatus* Newberry and Worthen, *Ibid.*, Vol. IV., Pl. III., Figs. 5, 8 (and 12?).  
 1883. *Sandalodus complanatus* St. John and Worthen, *Ibid.*, Vol. VII., p. 184, Pl. XII., Figs. 1-4.

Much discussion has arisen as to whether the fragmentary teeth described as "*Deltodus complanatus*" are truly referable to that genus, or belong to *Sandalodus*. A study of a considerable amount of material from the Burlington Group has convinced the writer that the above synonymy, which is taken from St. John and Worthen, is correct, and that the teeth figured as *D. complanatus* in the posthumous paper of Newberry<sup>1</sup> are fragments of *D. occidentalis* N. and W.

**DELTODUS** AGASSIZ.

Two species of *Deltodus* are found in mutual accompaniment throughout both the Burlington and Keokuk divisions of the Mississippian, and although their extreme forms are quite distinct (Plate 4, Figs. 38, 42), they are connected by intermediate gradations (Plate 5, Fig. 53), so that in the case of fragmentary teeth it is sometimes difficult to determine which of the two species is represented. Generally speaking, the teeth from the Burlington limestone are less perfectly preserved than those from the Keokuk, and chiefly for this reason the synonymy has become more or less involved. We propose to recognize the two forms under the names of *D. spatulatus* Newb. and Worth. and *D. occidentalis* (Leidy) respectively. The first-named ranges from the Kinderhook to the Keokuk inclusive, and the latter from the Burlington to the St. Louis Group, being particularly abundant in the Keokuk and Warsaw beds.

**Deltodus spatulatus** NEWBERRY and WORTHEN.

(Plate 4, Figs. 41, 42; Plate 5, Fig. 55.)

1866. *Deltodus spatulatus* Newberry and Worthen, Pal. Ill., Vol. II., p. 100, Pl. IX., Fig. 7.  
 1870. *Deltodus spatulatus* Newberry and Worthen, *Op. cit.*, Vol. IV., Pl. III., Fig. 11.  
 1870. *Deltodus alatus* Newberry and Worthen, *Ibid.*, p. 368, Pl. II., Fig. 6.  
 1870. *Cochliodus costatus* (*pars*) Newberry and Worthen, *Ibid.*, p. 364, Pl. III., Fig. 12 (*non* Fig. 10).  
 1879. *Deltodus spatulatus* J. S. Newberry, Ann. Rept. Geol. Surv. Indiana, 1876-78, p. 346.

<sup>1</sup> Trans. N. Y. Acad. Sci., Vol. XVI., 1897, p. 298, Pl. XXIV., Figs. 1-7.

1883. *Deltodopsis ? convolutus* St. John and Worthen, Pal. Illinois, Vol. VII., p. 165, Pl. XI., Figs. 11, 12.  
 1883. *Cochliodus costatus (pars)* St. John and Worthen, *Ibid* , p. 167.  
 1897. *Deltodus spatulatus* J. S. Newberry, Trans. N. Y. Acad. Sci., Vol. XVI., p. 299, Pl. XXIV., Figs. 8-11.

This species was originally described from the Burlington limestone of Quincy, Illinois, and the fact that it possessed a continuous range from the Kinderhook to the Keokuk inclusive has not previously been made known. In the earliest horizon the teeth are sparse and of relatively small size; in the Burlington group it is perhaps the most profuse of all *Deltodus* teeth; and although moderately large forms, such as is shown in Plate 4, Fig. 41, are occasionally met with in the Keokuk limestone, none are found in subsequent formations.

Of the posterior dental plates, the more strongly arched forms may be provisionally referred to the lower, and the less strongly arched to the upper jaw. The anterior dental plates belonging to this species have not been heretofore definitely recognized as such, no specimens having been found which show the two principal plates in natural association. An examination of a considerable amount of perfect material, however, has satisfied the writer that the strongly inrolled teeth described by St. John and Worthen under the name of *Deltodopsis ? convolutus*, and by Newberry and Worthen as the "second" tooth of *Cochliodus costatus*, fulfil all theoretical requirements for the anterior dental plate of *D. spatulatus*, and may be referred with utmost confidence to that species. The superficial characters of the two forms are identical, as already observed by St. John and Worthen, they are of corresponding proportions and curvature, and there is a perfect coadaptation of their grooved lateral edges, as any one may be convinced by fitting the two forms together in their natural position.

According to the view here advocated, the species known as *Deltodopsis ? convolutus* St. J. and Worthen becomes synonymous with *D. spatulatus*; and on removing from the so-called *Cochliodus costatus* Newb. and Worth. the form described by these authors as the "second" tooth, there remains as type of the latter species the narrow, doubly plicated form described by them as the "third" tooth. St. John and Worthen have expressed the opinion that the original authors were mistaken in regarding this as a "third," or posterior dental plate, believing it to represent the anterior of the two principal grinding plates; but evidence is lacking for associating it with any degree of assurance with other described species.

From the circumstance that the antero-lateral margin of the "second" or anterior dental plate in *D. spatulatus* is deeply grooved, as if for ligamentous union with a contiguous plate, Newberry and Worthen were led to infer the existence of a single dental element in advance of this "second" plate, thus postulating one more than the number of grinding organs characterizing the dentition of all *Cochliodonts* so far as known. *Cochliodus latus* Leidy furnishes us with perhaps the most complete example of *Cochliodont* dentition

that has come to light, and analogy with this form leads us to expect in advance of the anterior dental plate a series of *Helodus*-like teeth on either side above and below, and in front of these at the symphysis in at least one jaw, a series of bilaterally symmetrical teeth, arched in a single plane, and corresponding to the form described by Newberry as *Helodus coxanus*.<sup>1</sup> We are not yet in possession of adequate material, however, to attempt a theoretical restoration of the dentition of *Deltodus*, and the final solution of the problem must await the discovery of naturally associated parts.

In order that students may observe for themselves the nature of the material upon which the above identifications and conclusions are based, several specimens of *Deltodus* teeth are figured in the accompanying plates. In Plate 4, Fig. 38, is shown a small-sized but very perfect example of the posterior dental plate of *D. occidentalis*; in Plate 5, Fig. 53, a specimen of the form corresponding to the so-called *D. latior* St. J. and Worth. which we regard as a variety of *D. occidentalis* transitional between that species and *D. spatulatus*; and in Plate 4, Figs. 41, 42, are shown two rather large-sized examples of the posterior dental plate of *D. spatulatus*, one from the Burlington, and one from the Keokuk beds. Finally, in Plate 5, Fig. 55, a very excellent example is represented of the anterior dental plate of *D. spatulatus*, according to our interpretation of the so-called *Deltodopsis? convolutus* St. J. and W. As to the size attained by the posterior dental plates of *D. spatulatus*, we can only affirm that no specimens are known exceeding that figured by Newberry and Worthen under the name of *D. alatus*, but one of almost equal proportions is preserved in the Museum of the State University of Iowa at Iowa City.

*Formation and Locality.* — Kinderhook, Burlington, and Keokuk Groups; Iowa, Illinois, and Indiana.

### *Deltodus occidentalis* (LEIDY).

(Plate 4, Fig. 38; Plate 5, Fig. 53.)

1857. *Cochliodus occidentalis* J. Leidy, Trans. Amer. Phil. Soc. (2), Vol. XI, p. 88, Pl. V., Figs. 3-16.  
 1866. *Deltodus stellatus* Newberry and Worthen, Pal. Illinois, Vol. II, p. 97, Pl. IX., Fig. 2 (non Fig. 3?).  
 1883. *Deltodus occidentalis* St. John and Worthen, *Op. cit.*, Vol. VII, p. 150, Pl. IX., Fig. 9 (non Fig. 10).  
 1883. *Deltodus latior* St. John and Worthen, *Ibid.*, p. 145, Pl. IX., Figs. 11, 12.  
 1883. *Deltodus intermedius* St. John and Worthen, *Ibid.*, p. 153, Pl. IX., Figs. 14, 15.  
 1897. *Deltodus complanatus* J. S. Newberry, Trans. N. Y. Acad. Sci., Vol. XVI, p. 298, Pl. XXIV., Figs. 1-7.

The teeth referred to this species exhibit a wide range of variation, and while the more common expressions are quite distinct, there are arched forms like the type of the so-called "*D. latior*" which appear to connect the species

<sup>1</sup> Trans. N. Y. Acad. Sci., Vol. XVI, 1897, p. 301, Pl. XXIV., Fig. 24.

with *D. spatulatus*. In Plate 4, Fig. 38, is shown a very perfect posterior dental plate of the typical form, rather under the average size. Some very large examples have a width along the antero-lateral margin of nearly 6 cm., and in these much worn teeth the coronal contour is decidedly flatter than in immature specimens.

Messrs. Newberry and Worthen have figured the supposed anterior dental plate belonging to this species,<sup>1</sup> but the specimen appears to be too strongly enrolled for coadaptation with the antero-lateral margin of the posterior dental plate, and the same criticism applies to the specimen referred by St. John and Worthen<sup>2</sup> to a corresponding position. There is no record of the two principal dental plates of this species ever having been found in natural association, and it will require the careful study of much additional material before we can be fully satisfied as to the characters of the anterior components of the dentition. It is to be noticed that the initial coiling is much less marked in the teeth of this species than in most forms of *Deltodus* and *Sandalodus*.

*Formation and Locality.* — Burlington, Keokuk, Warsaw, and St. Louis Groups; Iowa and Illinois.

#### *Deltodus costatus* (NEWBERRY and WORTHEN).

1870. *Cochliodus costatus* Newberry and Worthen, Pal. Illinois, Vol. IV., p. 364, Pl. III., Fig. 10 (*non* Fig. 12).  
 1883. *Cochliodus costatus* St. John and Worthen, *Op. cit.*, Vol. VII., p. 167.

This species has not been previously reported from a higher horizon than the Burlington division of the Mississippian, but several examples from the Keokuk limestone are preserved in the United States National Museum and in the collections belonging to the State University of Iowa. Very similar teeth also occur in the Warsaw beds, and have been described as *Deltodus trilobus* by St. John and Worthen.<sup>3</sup> A tooth of the same general nature is also referred by the same authors to *D. occidentalis*, and is supposed by them to represent the anterior dental plate belonging to that species.<sup>4</sup> It is evident that the Warsaw forms last referred to are anterior dental plates, but attempts to correlate them with the posterior dental plates of other known forms are necessarily attended with great uncertainty.

*Formation and Locality.* — Burlington and Keokuk Groups; Iowa. (? Warsaw beds; Illinois.)

<sup>1</sup> Pal. Illinois, Vol. II., 1866, Pl. IX., Fig. 3.

<sup>2</sup> *Ibid.*, Vol. VII., 1883, Pl. IX., Fig. 10.

<sup>3</sup> *Ibid.*, Vol. VII., 1883, p. 148, Pl. IX., Fig. 8.

<sup>4</sup> Pal. Illinois, Vol. VII., 1883, Pl. IX., Fig. 10. (Warsaw limestone; Warsaw, Illinois.)

**Deltodus contortus** (St. John and Worthen).

(Plate 4, Figs. 37, 43.)

1883. *Taeniodus contortus* St. John and Worthen (*ex* L. G. de Koninck MS.), Pal. Illinois, Vol. VII, p. 76.

*Type*. — Posterior dental plate; Museum of Comparative Zoölogy.

The genus *Taeniodus*, with the type species of *T. contortus*, was held by its founders to be closely related to *Psephodus*, from which it was stated to be chiefly distinguished "by the pronounced differentiation of the coronal contour." Three species from the Mississippian series, besides the type, which is from the Lower Carboniferous of Belgium, were included under this genus by the original authors, but are distributed by A. S. Woodward in his Catalogue of Fossil Fishes between the genera *Psephodus* and *Deltodus*. We must express our complete concurrence with Dr. Woodward's views, and in order that others may judge of what the type species of *Taeniodus* is like, we here figure it for the first time, and would call attention to the close resemblance between it and the species of *Deltodus* illustrated in Plates IX. and X. of the seventh volume of the Illinois Palaeontology. These forms are interesting in that they show very distinctly the outlines of the individual teeth of which the large principal dental plates are composed.

*Formation and Locality*. — Lower Carboniferous limestone; Visé, Belgium.

**POECILODUS** M'COY.

This genus is peculiar in having the two posterior series of teeth in each jaw fused into a single much enrolled plate, the coronal surface of which is marked by more or less distinct transverse ridges and furrows. St. John and Worthen supposed that plates of this character pertained solely to the upper jaw, and regarded the triangular plates commonly referred to the genus *Deltoptychius* as constituting the lower dentition of *Poecilodus*. This idea, however, is not shared by any subsequent writers, and there is abundant evidence to show that the dentition of each jaw of *Poecilodus* was transversely ribbed. Accordingly, the species described by St. John and Worthen as "*Poecilodus springeri*" and *P. wortheni*, in the seventh volume of the Illinois Palaeontology, are properly transferred to the genus *Deltoptychius* of Agassiz.

**Poecilodus rugosus** NEWBERRY and WORTHEN.

1866. *Poecilodus rugosus* Newberry and Worthen, Pal. Illinois, Vol. II, p. 94, Pl. VIII, Fig. 13.

1866. *Poecilodus ornatus* Newberry and Worthen, *Ibid.*, p. 95, Pl. VIII, Fig. 14.

1883. *Chitonodus rugosus* St. John and Worthen, *Op. cit.*, Vol. VII, p. 112, 119.

The specimens at the command of Newberry and Worthen at the time of their original description of this species were very fragmentary, and more per-



fect material in the hands of St. John and Worthen in 1883 enabled them to add to our knowledge of it. The latter authors were, however, mistaken in their correlation of *Deltoptychius* plates with the lower dentition of this species, as is proved by the occurrence in the Keokuk limestone of two forms of teeth determinable as the upper and lower dental plates of *P. rugosus*. The lower dental plates are more strongly enrolled than the upper, and have more strongly marked transverse ridges. Some specimens appear to indicate, also, that the fusion between the two parts corresponding to the anterior and posterior dental plates of *Cochliodus* is less intimate in the lower than in the upper dentition. The largest of the compound upper dental plates examined by the writer exhibits a length along the inner margin of 4.5 cm., and a width along the antero-lateral border of 2 cm.

*Formation and Locality.* — Keokuk limestone; Iowa and Illinois.

### *Poecilodus tribulis* (ST. JOHN and WORTHEN).

1883. *Chitonodus tribulis* St. John and Worthen, Pal. Illinois, Vol. VII., p. 117, Pl. VII., Figs. 18-21.

A specimen belonging to the United States National Museum (Cat. No. 3496), and pertaining without doubt to this species, exhibits the characteristic fusion and transverse ribbing of *Poecilodus*, thus warranting its transfer to that genus. It appears not unlikely that the fragment described by Newberry and Worthen as *P. convolutus*<sup>1</sup> falls under the same specific limits as *P. tribulis*, but we are not prepared to unite the two under one head without the evidence of further material.

*Formation and Locality.* — Keokuk limestone; Iowa and Illinois.

### ANTERO-LATERAL AND SYMPHYSIAL TEETH OF UNDETERMINED COCHLIODONTIDAE.

Under the provisional generic names of *Helodus*, *Chomatodus*, and *Venustodus*, a large number of species have been described from the Mississippian series which are held to represent the anterior dentition of various *Cochliodonts*, but in only a few instances are they capable of correlation with the principal grinding plates by which these forms are best known.

In the case of *Cochliodus latus* Leidy, this species has been definitely ascertained to possess at least one, and possibly more than one series of elongated *Helodus*-like teeth in advance of the large grinding plates in the upper and lower jaws, and also a symphyisial series which has received the separate name of *Helodus coxanus* Newberry. Other teeth, which from their resemblance to "*Helodus coxanus*" may be referred to a corresponding position in the mouth, have been described under the names of *Chomatodus comptus* (*pars*) St. J. and

<sup>1</sup> Pal. Illinois, Vol. IV., 1870, p. 366, Pl. II., Fig. 9.

Worth., *Psephodus reticulatus* (*pars*) St. J. and Worth., *Helodus coniculus* Newb. and Worth., *H. triangularis*, and *H. acutus* Davis. To these must also be added the symmetrical tooth described below as *Helodus incisus*, sp. nov.

It has been shown by Traquair that the teeth named *Helodus planus* by Agassiz are certainly referable to *Psephodus magnus*, and Smith Woodward supposes that "most of the teeth from the Bristol Bonebed, named *Helodus laevissimus*, doubtless pertain to *Psephodus laevissimus*." The other teeth assigned to *Helodus*, however, are regarded by the same author as "probably common to one or more genera or species, and it is thus convenient, upon present evidence, to retain their provisional determinations." For the same reason, also, it is convenient to retain in a provisional sense most of the species which have been described under the name of *Chomatodus*.

### *Chomatodus inconstans* ST. JOHN and WORTHEN.

(Plate 4, Figs. 32-34.)

1875. *Chomatodus inconstans* St. John and Worthen, Pal. Illinois, Vol. VI., p. 360, Pl. X., Figs. 5-14.

1875. *Chomatodus varsouviensis* St. John and Worthen, *Ibid.*, p. 363, Pl. X., Figs. 1-4.

1875. *Chomatodus chesterensis* St. John and Worthen, *Ibid.*, p. 363, Pl. X., Figs. 15-17.

This species occurs typically in the St. Louis limestone, but it was noted by the Illinois palaeontologists that very similar forms are found also in the underlying Warsaw beds, and in the Chester limestone above, to which the names *C. varsouviensis* and *C. chesterensis* were given respectively. There can be little impropriety in assigning to the same species teeth of the form shown in Plate 4, Figs. 32-34, which are from the Keokuk Group, thus indicating a continuous existence from this horizon onward throughout the Lower Carboniferous. The original of the accompanying figures belongs to the United States National Museum, and a second specimen is preserved in the Museum of Comparative Zoology.

*Formation and Locality.* — Keokuk to Chester Groups; Mississippi Valley.

### *Helodus incisus*, sp. nov.

(Plate 5, Fig. 54.)

*Type.* — Isolated tooth; Museum of Comparative Zoology.

Teeth small, bilaterally symmetrical, more or less triangular in cross-section, the crown rising abruptly into a slightly recurved median eminence. Coronal surface uniformly smooth; posterior face strongly convex, anterior face very gently arched or almost plane, with a large  $\Lambda$ -shaped incision; faint ridges extend along the borders of the cavity on either side, and a third extends ver-

tically from the angle where they meet to the coronal apex. Lateral expansions of crown short, slightly tumid at their extremities.

The tooth represented in the accompanying figures, which corresponds to the above description, is of the same general form as those known under the names of *Helodus coxanus* Newb., *H. triangularis*, and *H. acutus* Davis, all of which may be referred with little hesitation to the symphyisial series of Cochliodont sharks. The slightly recurved apex in the species under discussion indicates that the series was feebly prehensile, and the triangular excavation to which the trivial title has reference, together with markings on the anterior face, show that the individual teeth of the series were very closely applied and slightly overrode one another. One other specimen, besides that shown in the figures, is preserved in the Cambridge collections, both having been obtained from the Subcarboniferous limestone of Salem, Indiana.

*Formation and Locality.* — Subcarboniferous ; Salem, Indiana.

#### ICHTHYODORULITES PRESUMABLY REFERABLE TO COCHLIODONTIDAE.

The most plausible interpretation which has been given of the peculiar Ichthyodorulites known as *Physonemus*, *Erismacanthus* (including *Gampsacanthus* and *Lecraecanthus*), *Dipriacanthus*, and certain forms of *Oracanthus*, is that they are head-spines corresponding to those already observed on either side of the head in the Permian *Menaspis*, and in one example of *Oracanthus armigerus* Traquair from the Calciferous sandstone of Eskdale, Dumfries. In our opinion the genus *Stethacanthus* should be placed in the same category with the above, and all these forms may be provisionally grouped with the Cochliodontidae. Various forms of *Physonemus* spines are arbitrarily distributed between *Petalodus* and *Polyrhizodus* by Jaekel,<sup>1</sup> but the evidence of actual association of parts, which is necessary for the confirmation of this conjecture, has not yet been forthcoming.

#### PHYSONEMUS M'Cor.

Very interesting stages of modification are displayed by the group of *Physonemus*-like spines throughout their existence in the Lower Carboniferous. The earliest and most primitive forms of *Physonemus* itself are found in the Kinderhook accompanied by small forms of *Stethacanthus*. The only known species, those described in the following pages, are of diminutive size, hook-shaped, and nearly destitute of surface ornamentation. *Erismacanthus* is also represented in the Kinderhook by two small comparatively unornamented species, and it is noteworthy that these have quite rudimentary anterior

<sup>1</sup> *Jaekel, O.*, Ueber die Organisation der Petalodonten (Zeitschr. deutsch. geol. Ges., Vol. LI., 1899, p. 285.

branches. The Burlington species of *Physonemus* and *Stethacanthus* display a marked increase in size, but they are feebly ornamented, and remain so throughout the stage represented by the Keokuk limestone. *Stethacanthus* seems to have attained its maximum size in the Keokuk Group, as *Physonemus* did in the Burlington, and a considerable falling off in this respect is true of both genera in the St. Louis division. The spines of *Stethacanthus* remain unornamented from the time of their first appearance in the Berea grit of Ohio until their extinction near the close of the Subcarboniferous, but those of *Physonemus* and *Erismacanthus* increase in complexity of ornamentation throughout the Mississippian series, ultimately displaying remarkable elaboration. An inspection of the forms illustrated in Plate XXII. of the sixth volume of the Illinois Palaeontology, and of the spines figured in the present contribution, will convince any one as to the correctness of these generalizations.

The spines in the typical species and in others resembling it are much laterally compressed, strongly arched or hook-shaped, with a broad base of insertion; the sides of the exerted portion are more or less ornamented with tuberculated longitudinal ridges, and small denticles are present upon the concave (posterior) border. This description applies to *P. arcuatus* M'Coy (the type species), *P. attenuatus* Davis, and *P. hamatus* (Agassiz), from the Carboniferous Limestone of Great Britain; and to the American forms described as *P. stellatus* Newberry, and *Drepanacanthus reversus* St. John and Worthen. Another group of spines which may be referred provisionally to the same genus is typified by such forms as the so-called *Drepanacanthus gemmatus* Newb. and Worth., *D. anceps* Newb. and Worth., *Xystracanthus acinaciformis* St. J. and Worth., *Physonemus gigas* Newb. and Worth., and the defences theoretically associated with the teeth of *Polyrhizodus rossicus* by A. Inostranzew<sup>1</sup> and O. Jaekel.<sup>2</sup> It is characteristic of the latter group of spines that they are forwardly curved, instead of backwardly, as in most Ichthyodorulites, a circumstance which appeared so anomalous to Newberry and Worthen as to warrant a generic separation from *Physonemus*. Transitional stages, however, showing the reversal of curvature from a posterior to an anterior direction, are to be observed in various species of *Stethacanthus* and *Oracanthus*, and for the present it seems best to extend the definition of *Physonemus* so as to include both groups. The two rod-like species from the Kinderhook limestone immediately to be described differ from all others in their more slender form and absence of ornamentation. They are undoubtedly to be interpreted as head-spines, a determination which is applicable to nearly all species of this genus.

<sup>1</sup> Travaux Soc. Nat. St. Petersb., Vol. XIX., 1888, pp. 1-18.

<sup>2</sup> Zeitschr. deutsch. geol. Ges., Vol. LI., 1899, p. 281, Fig. 5.

**Physonemus hamus-piscatorius**, sp. nov.

(Plate 5, Figs. 45, 46.)

*Type*. — Exserted portions of spines; Museum of Comparative Zoölogy.

Small hook-shaped spines, circular in cross-section, traversed by a small central pulp-cavity, and maintaining a nearly uniform diameter for the greater part of their length. External surface smooth or slightly roughened but not tuberculated, and no denticles present on either side. Inserted portion not observed.

The peculiar unciform spines shown in Plate 5, Figs. 45 and 46, from the Kinderhook limestone of Iowa, are the only examples at present known of this species. Both specimens are slightly abraded and afford no clue as to the nature of the inserted portion. The larger one is also fractured longitudinally for a considerable distance in such manner as to expose the tubular pulp-cavity, which in contrast to most species occupies a central position. The most striking differences displayed by the present form, however, are its circular cross-section and almost total absence of ornamentation. A small spine from the St. Louis limestone described by Messrs. St. John and Worthen as *Physonemus falcatus*, but which is probably the young of *P. arcuatus*, approaches the present form in its general outline, but differs notably in cross-section and other features. There is no reason to suppose that these spines are abnormally recurved, but on the contrary they may be looked upon as at once the most primitive, as they are also the earliest known representatives of *Physonemus*.

*Formation and Locality*. — Kinderhook limestone; Burlington, Iowa.

**Physonemus pandatus**, sp. nov.

(Plate 5, Fig. 44.)

*Type*. — Complete spine; Museum of Comparative Zoölogy.

Small, narrow, laterally compressed spines, the exserted portion erect and scarcely tapering for two thirds of its length, then becoming suddenly bent, more or less at right angles, but not decurved. External surface apparently unornamented, and denticles absent along the concave margin.

The unique example upon which this species is founded exhibits the whole of the exserted portion, and is broken off at the expanded base, the inference being that it was buried only to a slight extent in the integument. It is distinguished from the preceding species principally by its great lateral compression, and in its abrupt flexure without being curved downward toward the distal extremity. No traces are to be observed of superficial ornamentation, nor of denticles along the concave margin. This species, like the last, may be looked upon as a primitive forerunner of the group typified by *P. arcuatus*, immediately to be considered.

*Formation and Locality*. — Kinderhook limestone; Burlington, Iowa.

*Physonemus arcuatus* M'Coy.

(Text-figure 12.)

1848. *Physonemus arcuatus* F. M'Coy, Ann. Mag. Nat. Hist. (2), Vol. II., p. 117.  
 1855. *Physonemus arcuatus* F. M'Coy, Brit. Palaeoz. Foss., p. 638, Pl. III., Fig. 29.  
 1875. *Drepanacanthus reversus* St. John and Worthen, Pal. Illinois, Vol. VI., p. 456,  
 Pl. XIX., Fig. 5 (non Fig. 6).

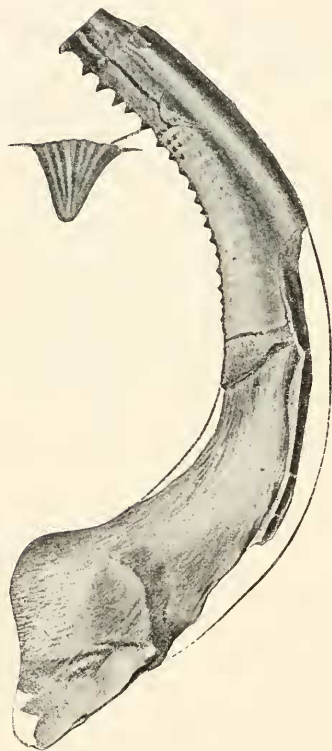


FIG. 12.

*Physonemus arcuatus* M'Coy. St. Louis limestone, Alton, Ill. Lateral aspect of spine,  $\times \frac{1}{4}$ , and single denticle,  $\times \frac{1}{7}$ .

1883. *Physonemus arcuatus* J. W. Davis, Trans. Roy. Dublin Soc. (2), Vol. I., p. 367, Pl. XLVII., Fig. 8.  
 1883. *Physonemus falcatus* St. John and Worthen, Pal. Illinois, Vol. VII., p. 252, Pl. XXIV., Fig. 6.  
 1883. *Drepanacanthus reversus* St. John and Worthen, *Ibid.*, p. 253, Pl. XXIV., Fig. 5.  
 1899. *Physonemus stellatus* J. S. Newberry, Monogr. U. S. Geol. Surv., Vol. XVI., p. 200, Pl. XXI., Fig. 12.  
 1902. *Physonemus arcuatus* C. R. Eastman, Bull. Mus. Comp. Zoöl., Vol. XXXIX., p. 87.

All of the spines referable to this species which have been previously figured are imperfect in this respect, that the superficial ornamentation has been very largely denuded, and the denticles along the concave margin either worn or broken away, thus obscuring their true relations. Although the example shown in the adjoining Text-figure has been somewhat injured, its general outline is well displayed, and enough of the ornamentation remains to leave no doubt as to its identity with the type species of this genus. The double row of striated denticles bordering the concave margin is fully as prominent as in typical examples, although abrasion has reduced many of the tubercles in size. One of the latter is represented seven times the natural size in the figure to the left of the spine.

Owing to the worn condition of the basal portion, it is not apparent to what depth the spine was inserted in the integument, but from some other specimens the writer has seen it is probable that it was not deeply implanted. There

can be no question that the spines belonging to this species are homologous with the compressed posterior branch of *Erismacanthus*, and reasoning from analogy, it is natural to suppose that in the group typified by *P. arcuatus* the spines were curved in the normal direction, that is to say, posteriorly. In *P. gemmatus*, *P. stellatus*, and *P. gigas*, on the other hand, appearances are in favor of Newberry's conclusion that the usual curvature was reversed, the anterior margin being concave, and the posterior convex. Enlightenment as to how this reversal may have been accomplished is furnished by a study of the conditions in *Stethacanthus* and the Kinderhook specimens of *Oracanthus vetustus*.<sup>1</sup>

*Formation and Locality.* — St. Louis limestone; Illinois, Missouri, and Indiana. Lower Carboniferous Limestone; Great Britain.

***Physonemus gemmatus* (NEWBERRY and WORTHEN).**

1866. *Drepanacanthus gemmatus* Newberry and Worthen, Pal. Illinois, Vol. II., p. 123, Pl. XIII., Fig. 1.  
 1889. *Drepanacanthus gemmatus* J. S. Newberry, Monogr. U. S. Geol. Surv., Vol. XVI., p. 195.

A spine as perfect as the type of this species is preserved in the United States National Museum, and agrees with it in the form of the inserted portion. This, according to Newberry, affords proof that the spine was curved forwards with the concave margin toward the front, as in *P. gigas* and some other forms. We are inclined to think that Newberry was correct in this view, but mistaken in supposing that *P. arcuatus* was curved in the same direction. The propriety of including these two species in the same genus has already been suggested by Newberry and Smith Woodward.

Spines of the present species are not altogether uncommon in the Keokuk limestone, and good examples may be seen in the Cambridge and Iowa State Museums. Apparently the tubercles along the concave margin never attained a size sufficient to be called denticles. As in *P. stellatus* Newb. and Worth., the pulp-cavity is not central in position, but placed slightly nearer the convex margin.

*Formation and Locality.* — Keokuk limestone; Iowa.

***Physonemus stellatus* (NEWBERRY and WORTHEN).**

1866. *Drepanacanthus (?) stellatus* Newberry and Worthen, Pal. Illinois, Vol. II., p. 125, Pl. XII., Fig. 7.  
 1875. *Batacanthus stellatus* St. John and Worthen, *Ibid.*, Vol. VI., p. 470, Pl. XXI., Figs. 1-3.

Complete spines of this species have never been figured. Newberry and Worthen were acquainted with but a single fragment of the distal portion, but

<sup>1</sup> Newberry, *J. S.*, Trans. N. Y. Acad. Sci., Vol. XVI., 1897, p. 285, Pl. XXII., Fig. 3.

noticed its resemblance in ornamentation to that of *P. gemmatus* from the same horizon. The specimens figured by St. John and Worthen are likewise from the distal third of the spine. The total length, as shown by one or two good examples in Iowa City, is really much longer than these authors supposed, and the breadth nearly equals that of *P. gemmatus*. The proportions of the two species are in fact very similar, the chief differences consisting in ornamental details, form of cross-section, and the greater development of tubercles along the concave border in the present species. In the distal portion of the spine these tubercles frequently appear as strong acuminate denticles. The pulp-cavity remains open for a short distance on the convex side near the base, and continues close to this side throughout the spine until near the tip. Like the preceding species, it is extremely probable that the spines of *P. stellatus* were curved forwards.

*Formation and Locality.* — Keokuk limestone; Iowa and Illinois.

LIST OF NORTH AMERICAN SPECIES OF PHYSONEMUS.

Name of Species.	Kinderhook.	Burlington.	Keokuk.	St. Louis.	Chester.	Coal Measures.
1. <i>P. hamus-piscatorius</i> Eastman . . . . .	X	—	—	—	—	—
2. " <i>pandatus</i> Eastman . . . . .	X	—	—	—	—	—
3. " <i>gigas</i> Newb. and Worth. . . . .	—	X	—	—	—	—
4. " <i>gemmatus</i> (Newb. and Worth.) . . . .	—	—	X	—	—	—
5. " <i>stellatus</i> (Newb. and Worth.) . . . .	—	—	X	—	—	—
6. " (?) <i>baculiformis</i> (St. J. and Worth.) . . . .	—	—	X	—	—	—
7. " (?) <i>necis</i> (St. J. and Worth.) . . . .	—	—	X	—	—	—
8. " <i>arcuatus</i> M'Coy . . . . .	—	—	—	X	—	—
9. " <i>acinaciformis</i> (St. J. and Worth.) . . . .	—	—	—	—	—	X
10. " <i>anceps</i> (Newb. and Worth.) . . . .	—	—	—	—	—	X
11. " <i>asper</i> Eastman . . . . .	—	—	—	—	—	X

ERISMACANTHUS M'COY.

The two European and one American species of this genus that have been described are evidently very closely related to the type of *Physonemus*, but differ in that the spines are divaricated, the two branches extending in opposite directions in the same vertical plane. The imperfect *Ichthyodondites* known



as *Gampsacanthus*, *Leacanthus*, and *Dipriacanthus* appear to be of the same general nature, and may be provisionally regarded as the dissociated anterior branches belonging to *Erismacanthus*. The Kinderhook species of this genus are small and exceedingly primitive as compared with the highly ornamented spines occurring in the St. Louis limestone, some of which attain the astonishing length of over 20 cm., and are provided with very large-sized denticles along the anterior arm. The forms included under this genus are referable to the head region with even greater certainty than those of *Physonemus*, and evidently occurred in pairs, whereas the latter would seem to have occupied a median position.

***Erismacanthus barbatus*, sp. nov.**

(Plate 5, Fig. 47.)

*Type*. — Isolated and fragmentary spine; Museum of Comparative Zoölogy.

Spines small, very much laterally compressed, smooth or with faint longitudinal striae, and without denticles or tuberculations of any kind. Principal portion of spine gently arched, gradually tapering, and giving off two spiniform branches of unequal size from the convex margin.

This peculiar and in many respects primitive form of *Erismacanthus* is known by the solitary example shown of the natural size in the accompanying figure. It is excessively flattened, and consists of a gently arched portion corresponding to the denticulated posterior branch of other species, and of two rudimentary anterior branches, each with a thickened border and elevated ridge. A slight differentiation in the superficial ornament, which in later species becomes very pronounced, is already indicated in this early form, in that the main or posterior branch is feebly striated and the two anterior projections quite smooth.

*Formation and Locality*. — Kinderhook limestone; Burlington, Iowa.

***Erismacanthus maccoyanus* ST. JOHN and WORTHEN.**

1875. *Erismacanthus maccoyanus* St. John and Worthen, Pal. Illinois, Vol. VI., p. 461, Pl. XXII., Figs. 1, 2, 4 (non Fig. 3).

This species has been known hitherto by only a few very diminutive spines from the St. Louis limestone, none of the specimens in the hands of Messrs. St. John and Worthen exceeding one inch in length. Whether all of the examples figured by these authors pertained to a single species was indeed questioned by them, on account of differences in the form and arrangement of the posterior denticles. Their views concerning the imperfect spine shown in Plate XXII., Fig. 3, of the seventh volume of the Illinois Palaeontology are thus expressed: "Whether the approximate arrangement of the denticles observed in the above specimen is indicative of specific distinctness from its associates we have not the means for determining; it is, however, probable that these closely arranged

denticles gradually merge into the widely spaced and finally obtuse tubercles occurring near the base of the spine, as shown in fig. 1 a, and fig. 4 a."

Specimens that have come to light since the time of St. John and Worthen lead to the conclusion that the original of their Plate XXII., Fig. 3, which is peculiar in having "approximated denticles" along the posterior spine, is the young of a gigantic species recently described as *E. formosus*. It need only be remarked here that the additional material proves conclusively that the spines of *Erismacanthus* occurred as rights and lefts, and are presumably referable to the head-region.

The occurrence of *E. maccoyanus* in other formations than the St. Louis limestone has not been previously reported. A small branched spine, however, from the Kinderhook limestone of Le Grand, Iowa, belonging to the Museum of Comparative Zoology, appears referable to this species, notwithstanding its weathered condition. At all events, it agrees with the latter in size and form, but we are unfortunately left in doubt with regard to the superficial ornamentation.

*Formation and Locality.* — Kinderhook Limestone; Iowa. St. Louis Limestone; Missouri.

### *Erismacanthus formosus* EASTMAN.

(Text-figure 13.)

1875. *Erismacanthus maccoyanus* (errore) St. John and Worthen, Pal. Illinois, Vol. VI., p. 461, Pl. XXII., Fig. 3.

1902. *Erismacanthus formosus* C. R. Eastman, Amer. Nat., Vol. XXXVI., p. 850, Text-fig. 1.

This, the largest known species of *Erismacanthus*, is interesting on account of its relatively gigantic size, being nearly seven times as large as *E. maccoyanus*,

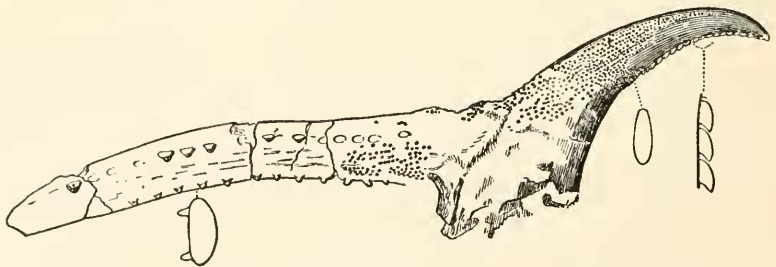


FIG. 13.

*Erismacanthus formosus* Eastm. St. Louis limestone, St. Louis, Mo. Outer face of cephalic spine belonging to the left side of the head,  $\times \frac{1}{2}$ .

which it accompanies in the same formation, and twice the size of *E. jonesi* McCoy, the largest European species. It is also interesting in having paralleled

the condition observed in certain Mesozoic Teleosts, such as *Coccodus* from the Lebanon Cretaceous, in which very similar head-spines are developed, and oriented in the same way, one on either side of the head. Appearances suggest that the long and stout anterior branch in the present form was for the most part buried in the integument, only the double row of robust conical denticles protruding, but the posterior spine was probably entirely exposed. The typical example of this species, shown in Text-figure 13 and now deposited in the Museum of Comparative Zoölogy, exhibits a total length of no less than 21.5 cm.

*Formation and Locality.* — St. Louis Limestone; Missouri.

### STETHACANTHUS NEWBERRY.

*Definition (emend.).* — Spines broad, much laterally compressed, triangular or falcate in outline, deeply inserted. The elongated basal portion thin-walled and occupied by a very large internal cavity which extends upward nearly to the apex; exerted portion terminated at one end by a strong, often tumid shoulder, and rising at the other by a gradual curve into an acuminate summit. Surface of spine having a rough, fibrous appearance and marked in the basal portion by coarse vascular impressions. Internal structure distinctly fibrous, owing to the fan-shaped radiation of numerous fine tubules from the apex toward the basal portion. Apex usually inclined posteriorly (*i. e.*, away from the tumid "shoulder"), but sometimes erect, or even slightly inclined forwards.

The peculiar class of dermal structures which are recognized under the name of *Stethacanthus* display quite uniform characters throughout their range from the Waverly to near the summit of the Mississippian series. They were regarded as pectoral fin-spines by Newberry,<sup>1</sup> who was under the mistaken impression that they were not bilaterally symmetrical, and was further misled by the fortuitous association on the same slab of a spine of *S. tumidus* with fin-rays of an Actinopterygian fish. There is no reason for supposing that they were situated elsewhere than in the median line of the body, either along the back or at the base of the head.

On considering the probable relationships of *Stethacanthus*, we are struck immediately with its resemblance to *Physonemus*, especially such forms as *P. gigas*, nor can a certain similarity be denied to the remarkable Kinderhook spine described by Newberry as *Oracanthus vetustus*, to which reference has already been made. In the latter form the base is much produced in an anterior direction, forming a most efficient anchorage in the soft parts for the exerted portion, and it is noteworthy that the tip of the exerted portion is slightly curved forwards. The same condition of things is developed to a somewhat lesser extent in *Physonemus gigas*, in which there is even an incipient "shoulder" at the base of the concave (anterior) margin. A more

<sup>1</sup> Monogr. U. S. Geol. Surv., Vol. XVI., 1889, p. 198.

advanced stage of modification than this is exemplified by the various species of *Stethacanthus*, the basal portion having become much elongated and the anterior "shoulder" very conspicuous. In the more primitive forms the summit projects but slightly above the line of insertion, and the concave margin is very gently curved. Gradually the summit becomes more strongly and abruptly elevated, finally assuming an erect or even recurved position, as in *S. altonensis* and some other species.

The anterior tumid portion or "shoulder" which terminates the exerted portion in the line of the body-wall in front, doubtless served as a buttress for strengthening the attachment of the spine in the soft parts and forms the initial portion of the cutwater. The depth to which the spine was inserted, or, in other words, the line of the body-wall, is denoted by the regular termination of the coarse vascular impressions which are limited to the basal portion. The latter is always more or less produced in advance of the anterior shoulder, and in some species it is also produced posteriorly beyond the point where the exerted portion enters the integument, as shown in Newberry's figure of *S. altonensis*.<sup>1</sup> This author's observation that "the base shows the outline of what seems to be a spheroidal head that fitted into the socket of an articulation" may be dismissed as having no foundation of fact, and probably arose from deceptive appearances.

The Devonian spines known as *Acautholepis* and *Phlyctaenacanthus* also exhibit a very large internal cavity, and appear to have been inserted in an essentially similar manner.

### ***Stethacanthus altonensis* (St. JOHN and WORTHEN).**

1875. *Physonemus altonensis* St. John and Worthen, Pal. Illinois, Vol. VI, p. 454, Pl. XIX., Figs. 1-3.  
 1875. *Drepanacanthus reversus (errore)* St. John and Worthen, *Ibid.*, p. 457, Pl. XIX., Fig. 6 a.  
 1889. *Stethacanthus altonensis* J. S. Newberry, Monogr. U. S. Geol. Surv., Vol. XVI, p. 198, Pl. XXIV.

This, the typical species, appears to be restricted to the St. Louis limestone, and in its larger size and nearly erect summit represents a more advanced stage of modification than the Burlington species. A specimen larger than any described belongs to the private collection of Dr. G. Hambach, in St. Louis, and has a total length of 24 cm., the basal portion being conspicuously produced beyond the limits of the exerted part both in front and behind. The walls have a uniform thickness of about 2 mm. throughout, except along the cutwater and posterior margin of the exerted portion. Newberry's statement that these spines exhibit a want of bilateral symmetry is clearly erroneous.

*Formation and Locality.* — St. Louis limestone; Illinois and Missouri.

<sup>1</sup> Monogr. U. S. Geol. Surv., Vol. XVI, 1889, Pl. XXIV.

**Stethacanthus productus** NEWBERRY.

(Text-figure 14.)

1875. *Physonemus gigas* (errore) St. John and Worthen, Pal. Illinois, Vol. VI., Pl. XVII., Figs. 7-9.  
 1897. *Stethacanthus productus* J. S. Newberry, Trans. N. Y. Acad. Sci., Vol. XVI., p. 291, Pl. XXIII., Figs. 2, 2.  
 1897. *Stethacanthus compressus* J. S. Newberry, *Ibid.*, p. 292, Pl. XXIII., Figs. 3, 4.

*Type.* — Imperfect spine; Museum of Chicago University.

The spines referred to this species are characterized by having the concave margin very gently curved, in consequence of which the apex is much inclined backwards. The smaller spines described by Newberry as *S. compressus* appear to be the young of the species under discussion, and it need scarcely be remarked that their correlation by this author with the pectoral and pelvic fins is entirely fanciful. Spines having the same form as *S. productus*, but of much smaller size, occur in the Kinderhook limestone of Iowa. The species described by Messrs. St. John and Worthen as *Physonemus depressus*, *P. carinatus*, and *P. gigas* (in part) are distinguished from one another and from *S. productus* in only minor details, and the types are extremely fragmentary. Nevertheless, it is convenient to regard the Kinderhook species as distinct from the Burlington, provisionally at least, and as representing the earliest and most primitive expressions of the genus. The Burlington species exhibit a marked increase in size, and in the next succeeding formation, the Keokuk, the maximum appears to have been attained by spines such as the one represented in the accompanying Text-figure.

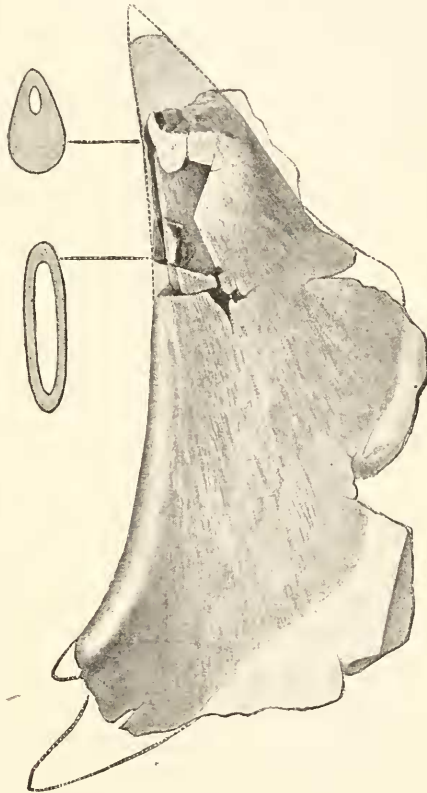


FIG. 14.

*Stethacanthus productus* Newb. Keokuk limestone, Keokuk, Iowa. Lateral aspect of spine, with cross-sections of summital portion,  $\times \frac{1}{3}$  (approximately).

The original of this figure belongs to the United States National Museum at Washington, and was collected by Mr. L. A. Cox from a quarry in the Keokuk limestone on Cedar Street in the city of Keokuk. The spine was nearly perfect when found, but was injured in extricating it from the matrix. The shaded portion of the summit is now to be observed only in impression on the underlying slab, and the extreme tip is restored from a pencil sketch made by Mr. Cox according to his recollection. The dotted lines which are intended to show the anterior "shoulder" and basal projection as they occur in most species, are to be understood as conjectural, and a reliable index as to the elevation of the summital portion is therefore wanting. The width across the anterior shoulder at the point where it is broken off is no less than 3.7 cm., and it is in this region that the greatest thickness of the walls occurs. The thickness of the exerted portion is indicated by the two sections that are given, the upper one of which shows the approximation of the pulp-cavity toward the concave margin. The total length of the part preserved is 32 cm., and the total height 12 cm. Some hesitation is felt in referring this specimen to *S. productus*, but this course seems preferable to recognizing it as a distinct species.

*Formation and Locality.*— Burlington and Keokuk Groups; Iowa.

***Stethacanthus depressus* (ST. JOHN and WORTHEN).**

(Text-figure 15.)

1875. *Physonemus depressus* St. John and Worthen, Pal. Illinois, Vol. VI., p. 452, Pl. XVIII., Fig. 3.

Only a few imperfect examples of this species were known to its authors, all of them under two inches in length, and recognized as distinct from other

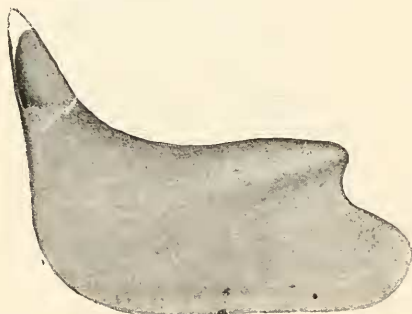


FIG. 15.

*Stethacanthus depressus* (St. J. and W.). Waverly sandstone, Marshall, Mich. Right lateral aspect of spine,  $\times \frac{1}{3}$ .

forms chiefly on account of the "shoulder" being broadly rounded from side to side, and the concave margin of the exerted portion being very gently curved. The complete outline of the spines belonging to this species is well shown in several specimens from the Kinderhook of Le Grand, Iowa, now in the collections of the United States National Museum at Washington. It is also well displayed in the original of Text-figure 15, which belongs presumably to the same species, and is from the Waverly sandstone of Marshall,

Calhoun County, Michigan. Although the actual substance of this spine has

been considerably removed by chemical decomposition, yet where the surface is preserved it is seen to be covered with vascular impressions extending well up toward the superior margin, thus indicating that the spine was deeply implanted.

*Formation and Locality.* — Kinderhook ; Iowa. Waverly sandstone ; Michigan.

### ***Stethacanthus erectus*, sp. nov.**

(Plate 3, Fig. 29.)

*Type.* — Imperfect spine ; United States National Museum.

A species of about the same size as *S. depressus*, and differing from it in having the concave margin more abruptly curved, the exerted portion rising into a narrow and acuminate apex.

It is unfortunate that the specimen selected as the type of this species is not more perfectly preserved, as it seems to represent an intermediate stage in the modifications affecting the exerted portion of these peculiar spines, being in fact transitional between low forms like *S. compressus*, *S. carinatus*, *S. depressus*, etc., and those in which the apex is recurved, like *S. proclivus* and *S. altonensis*. The anterior shoulder and greater part of the basal portion of this unique specimen have been broken away, but it is probable that the complete outline would show that the base was produced for some distance posteriorly beyond the hinder wall of the summital portion, as in *S. altonensis* and some other species. The total height of the part preserved is 3 cm., thus indicating a species of about the same size as the preceding.

*Formation and Locality.* — Kinderhook limestone ; Iowa.

## CESTRACIONTIDAE.

### HOMACANTHUS AGASSIZ.

This genus, which is evidently closely akin to *Ctenacanthus*, is thus defined by A. S. Woodward : "Dorsal fin-spines of small size, slender, more or less arched, laterally compressed, and gradually tapering distally ; sides of exerted portion ornamented with few, large, smooth, widely spaced longitudinal ridges ; a similar ridge also forming a large anterior keel ; posterior face with a double series of large, downwardly curved denticles." The only American species that have been referred to *Homacanthus* have since been removed to other genera, but true representatives of this genus are apparently indicated by the spines described in the following paragraphs.

**Homacanthus delicatulus, sp. nov.**

(Plate 3, Fig. 28; Plate 5, Fig. 59.)

*Type.* — Isolated spine; Museum of Comparative Zoölogy, Cambridge.

*Definition.* — Spines very diminutive, erect, deeply inserted; base of exerted portion relatively broad, distal extremity acute, sides ornamented with not more than five or six straight longitudinal ridges.

The very minute and nearly perfect specimen which is here referred to *Homacanthus* might at first sight be assumed to belong to a young individual of *Ctenacanthus*, in which case it would correspond to the extreme tip of an adult spine. But even the distal extremity of all *Ctenacanthus* spines is distinctly tuberculated, and moreover, the costae appear too divergent, and the base of insertion too broad for this specimen to be regarded as a young form of *Ctenacanthus*. Besides, the Kinderhook species of *Ctenacanthus* are pretty well known, and there are none to which this small form corresponds even approximately, hence we may look upon it as belonging to *Homacanthus*.

The spine has a total length of about 1.8 cm., and maximum width of only 3 mm. The inserted portion is relatively very long and tapering, and the exerted portion has a narrow triangular form, the two portions being separated by a very oblique and prominently marked line of insertion. The lateral face is occupied by five smooth and continuous longitudinal costae, and two or three additional ones unite to form the anterior keel. Growth of the costae seems to have taken place by the coalescence of dentine tubercles formed just below the line of insertion, as shown in Plate 5, Fig. 59. The absence of denticles along the posterior margin is to be accounted for by the effects of weathering or abrasion, or both. Some resemblance is to be noted between this spine and one of those figured by J. W. Davis as *H. microdus* from the Lower Carboniferous limestone of Armagh, Ireland (Trans. Roy. Dublin Soc. (2), Vol. I., 1883, Pl. XLVIII., Fig. 8.)

*Formation and Locality.* — Kinderhook limestone; Le Grand, Iowa.

**Homacanthus acinaciformis, sp. nov.**

(Plate 5, Fig. 58.)

*Type.* — Exserted portion of spine; Museum of Comparative Zoölogy.

Spines comparatively small, slender, gradually tapering, gently and uniformly arched; lateral surface with five or six smooth continuous longitudinal ridges; posterior denticles slender, rather widely spaced.

This species is noticed here principally for the sake of comparison with the preceding, and to illustrate the difference in degree of curvature pervading various spines included under the same genus. Indeed, if we may depend upon the determinations of J. W. Davis, spines belonging even to a single



species of *Homacanthus* vary considerably in curvature.<sup>1</sup> The present form may also be compared with the spines referred by Davis and Newberry to the genus *Hoplonychus*, which is scarcely distinct from *Homacanthus*. The single American species assigned to *Hoplonychus* was originally described by Newberry as *Ctenacanthus parvulus*, and occurs in the Cleveland Shale (Upper Devonian) of Ohio.

*Formation and Locality.* — Chemung Group; Warren, Pennsylvania.

### CTENACANTHUS AGASSIZ.

In a recent number of this Bulletin (Vol. XXXIX., No. 3), several species of *Ctenacanthus* were described from material belonging to the United States National Museum, and derived from the Kinderhook limestone of Iowa. Some of these spines had formed part of the Government display at the Omaha and other expositions, previous to their coming to Cambridge, and when placed in the hands of the writer for description the authorities at Washington were unable to furnish a record of the exact locality whence they were obtained. Since their description was published, however, information has been received from Mr. Charles Schuchert, who purchased the specimens, that the types of *C. longinodosus*, *C. lucasi*, *C. decussatus*, and *C. solidus*, together with the figured specimens of *C. spectabilis* and *C. venustus*, were collected by a Mr. McCabe from the Kinderhook quarries at Le Grand, near Marshalltown, in Marshall County, Iowa. A description of the formation as exposed in this vicinity will be found in Volume VII., pp. 221-226, of the Iowa Geological Survey Annual Reports (1896).

### FRAGMENTS OF DERMAL ARMOR AND OTHER UNIDENTIFIED REMAINS.

Portions of calcified cartilage, detached tubercles, bosses, and dermal plates are of not infrequent occurrence in nearly all members of the Mississippian series, being particularly abundant in the Kinderhook and St. Louis limestones; and in a few instances nearly complete cartilaginous and osseous jaws have been brought to light, some of them dentigerous. None of these fragmentary remains are capable of satisfactory determination, although the more characteristic of them have received provisional designations, such as *Petrodus*, *Stemmatias* (*Stemmatodus* St. J. and Worth. *non* Heckel), *Mazodus*, etc. The wide range of form and ornamentation displayed by these bodies is remarkable, and it is evident that Carboniferous fishes possessed a much more varied external covering than their Devonian predecessors.

The survival of moribund Arthrodires during at least a part of the Kinderhook is witnessed by occasional dermal plates displaying the structure and tuberculation characteristic of this group. An examination of weathered and

<sup>1</sup> Trans. Roy. Dublin Soc. (2), Vol. I., p. 361, Pl. XLVIII., Figs. 7-9.

fractured specimens reveals the interesting fact that the growth of these plates was by secretion of new layers of bony tissue on both sides of the old, above and below, thus proving that the entire plate was covered by the integument. In no other way can we explain the presence of successive tuberculated layers underneath the external one, nor the regularly laminated structure of the plates as seen in cross-section. A number of undoubted Arthrodire plates from the Kinderhook near Burlington, Iowa, were collected many years ago by Messrs. Giles, Wachsmuth, and St. John, and are now preserved in the Cambridge Museum of Comparative Zoölogy.

As if in mimicry of the tuberculated covering of Arthrodires, rugose dermal plates were developed by their Elasmobranch contemporaries in the Kinderhook, probably through concrescence and fusion of shagreen granules; and their resemblance to the former is often so close that an examination of the microscopical structure is necessary to distinguish them. An example of such a plate, with symmetrical outlines and simulating the tuberculation of Arthrodires, is shown in Plate 5, Fig. 50. The more common form of dermal tubercles,



FIG. 16.

Dermal Plate of an undetermined Elasmobranch, in lateral and superior aspects,  $\times \frac{1}{2}$ . Kinderhook limestone, Burlington, Iowa.

however, is acutely or obtusely conical, as exemplified by *Petrodus* or by the spiniform bodies shown in Plate 5, Figs. 56 and 57. Occasionally bodies are found having the form of elongated eminences, either symmetrical like that shown in Text-figure 16, or abruptly truncated on one side, as if they had been disposed in pairs, and recalling the dermal head plates of *Myriacanthus* and other Chimaeroids. Many of these tuberculated plates may be referred with considerable confidence to Chimaeroids, notwithstanding the fact that they are unaccompanied by dental plates. It is a remarkable circumstance that Chimaeroid jaws, which occur in great profusion in the Middle and Upper Devonian, are wholly unknown in rocks of Carboniferous age, and Dipnoans are conspicuously absent in the lower members of the same series. An explanation of their sudden disappearance at the close of the Devonian is possibly to be found in the change that took place from shallow to deep water conditions with the resultant migration of littoral forms.

In Text-figure 17 is shown of twice the natural size a peculiar fossil from one of the "fish-beds" near Burlington, Iowa, stratigraphically near the dividing line between Upper Devonian and typical Kinderhook. It is one of a score or more precisely similar bodies which were collected by St. John, Wachsmuth,

S. A. Miller, and others at this locality a number of years ago, and more recently Prof. J. A. Udden has collected further specimens of the same sort near Burlington. The nature of these bodies is entirely problematical, some of the best-known palaeontologists who have examined them being unable to express any decided opinion concerning them. Their finely laminated structure does not in the least indicate them to be of vertebrate origin, nor can they be satisfactorily classed with plant remains. The suggestion that they may have to do with Molluscan remains is as compatible as any with the internal structure, but we are at a loss to identify them with the usual hard parts, not even excepting the beaks of Nautiloids. Any attempt to homologize them with any known Crustacean structure is equally baffling. Owing to the not uncommon occurrence of these bodies in accompaniment with fish-remains in the Kinderhook, they are at least worthy of passing notice, and the accompanying figure is given in the hope that some clue may be found concerning their true nature.



FIG. 17.

Problematical fossil from the Kinderhook limestone of Burlington, Iowa,  
 $\times \frac{3}{1}$ .

## EXPLANATION OF PLATES.

## PLATE 1.

- Fig. 1. *Campodus variabilis* (N. and W.). Missourian; Kansas and Nebraska. Supposed lower dentition,  $\times \frac{1}{3}$ . The symphyseal series is photographed from an actual specimen obtained by Prof. E. H. Barbour from the Atchison shales of Cedar Creek, Cass County, Nebraska; the mandibular rami are photographed from a plaster cast of the specimen described by St. John and Worthen in the sixth volume of the Illinois Palaeontology. The original of the latter specimen was derived from the Missourian of Topeka, Kansas, and is now preserved in the private collection of O. H. St. John, at Raton, New Mexico.
- Fig. 2. *Cestracion francisci* Girard. Recent; Pacific Ocean. Lower dentition,  $\times \frac{1}{1}$ . The cuspidate anterior and symphyseal teeth are well shown by this specimen.

## PLATE 2.

All figures are of the natural size, and photographed from the original specimens without retouching.

- Fig. 3. *Cladodus occidentalis* Leidy. Atchison shales (Missourian); Table Rock, Nebraska. Outer coronal face of imperfect tooth, the lateral denticles and a portion of the root being broken away.
- Fig. 4. *Cladodus knightianus* (Cope). Chase formation (Permo-Carboniferous); Blue Springs, Nebraska. Inner coronal face of imperfect specimen.
- Fig. 5. *Peripristis semicircularis* (Newb. and Worth.). Atchison shales (Missourian); South Bend, Nebraska. Uninjured side of pathologic upper tooth.
- Fig. 6. *Peripristis semicircularis* (Newb. and Worth.). Atchison shales (Missourian); Louisville, Cass County, Nebraska. Anterior aspect of upper dental plate, the root partially embedded in matrix.
- Fig. 7. *Peripristis semicircularis* (Newb. and Worth.). Atchison shales (Missourian); South Bend, Cass County, Nebraska. Anterior aspect of upper dental crown, tilted slightly upward.
- Fig. 8. *Cladodus occidentalis* Leidy. Neosho formation (Permo-Carboniferous); Roca, Lancaster County, Nebraska. Apical portion of crown, showing striated inner face.

- Fig. 9. *Cladodus occidentalis* Leidy. Atchison shales (Missourian); Springfield, Sarpy County, Nebraska. Fragmentary basal portion viewed from the inner face, with lateral denticles preserved on one side, and showing prominent nutrient foramina of root.
- Fig. 10. *Ctenoptychius occidentalis* (St. J. and Worth.). Atchison shales (Missourian); Richfield, Sarpy County, Nebraska. Outer coronal face of a weathered specimen, the root broken away.
- Fig. 11. *Fissodus inaequalis* (St. J. and Worth.). Atchison shales (Missourian); Peru, Nemaha County, Nebraska. Inner coronal face of same specimen as shown in Plate 3, Fig. 26.
- Fig. 12. *Fissodus dentatus*, sp. nov. Missourian; Topeka, Kansas. Outer coronal face of tooth, the root broken away. Marks of contact with next older tooth are distinctly shown, serrations of lateral edges but faintly, in the photograph.
- Fig. 13. *Janassa unguicula*, sp. nov. Atchison shales (Missourian); Cedar Creek, Cass County, Nebraska. Outer coronal face of tooth, the root broken away. The portion overlapped by next older tooth in front is indicated by the darker area at the base of crown.
- Fig. 14. *Helodus rugosus* Newb. and Worth. Base of Cottonwood or summit of Atchison shales (Missourian); Table Rock, Pawnee County, Nebraska. Inner face of nearly perfect tooth.
- Fig. 15. *Campodus variabilis* (Newb. and Worth.). Neosho formation (Permo-Carboniferous); Roca, Lancaster County, Nebraska. Coronal surface of supposed postero-lateral tooth, differing somewhat from any described by St. John and Worthen.
- Fig. 16. *Campodus variabilis* (Newb. and Worth.). Atchison shales (Missourian); Louisville, Cass County, Nebraska. Coronal surface of a slightly asymmetrical tooth with feebly developed buttresses along the outer margin, and most nearly agreeing with the tooth figured by St. John and Worthen in Pl. VIII, Fig. 4, of the sixth volume of the Illinois Palaeontology.
- Fig. 17. *Petalodus alleghaniensis* Leidy. Atchison shales (Missourian); South Bend, Cass County, Nebraska. Anterior (outer) face of a broad-rooted and symmetrical tooth presumably situated in the azygous series in front. The opposite face of the same specimen is shown in Plate 3, Fig. 27.
- Fig. 18. *Petalodus alleghaniensis* Leidy. Base of Cottonwood or summit of Atchison shales (Missourian); Table Rock, Pawnee County, Nebraska. Posterior aspect of fragmentary specimen showing difference in form of root as compared with teeth occupying a position in the median azygous in front.
- Fig. 19. *Deltodus angularis* Newb. and Worth. Permo-Carboniferous; Blue Springs, Gage County, Nebraska. Coronal surface of posterior dental plate referred to the right mandibular ramus.
- Fig. 20. *Strebloodus angustus*, sp. nov. Atchison shales (Missourian); South Bend, Cass County, Nebraska. Coronal surface of posterior dental plate referred to the left ramus of the upper jaw.
- Fig. 21. *Janassa maxima*, sp. nov. Atchison shales (Missourian); Richfield, Sarpy County, Nebraska. Posterior (inner) coronal face of a fractured and

unsymmetrically worn specimen, presumably referable to one of the antero-lateral series of the upper jaw. The opposite face of the same specimen is shown in Pl. 3, Fig. 24.

- Fig. 22. *Ctenacanthus amblyxiphias* Cope. Atchison shales (Missourian); South Bend, Cass County, Nebraska. Left lateral aspect of fragmentary spine referable to the first dorsal fin.
- Fig. 23. *Ctenacanthus amblyxiphias* Cope. Atchison shales (Missourian); Louisville, Cass County, Nebraska. Left lateral aspect of fragmentary spine showing characteristic ornamentation.

The original of Fig. 12 is preserved in the Museum of Comparative Zoölogy at Cambridge, the remainder in the Museum of Nebraska State University at Lincoln.

### PLATE 3.

[All figures are of the natural size.]

- Fig. 24. *Janassa maxima*, sp. nov. Anterior (outer) coronal aspect of same specimen as shown in Pl. 2, Fig. 21.
- Fig. 25. *Peripristis semicircularis* (N. and W.) Summit of Chester limestone; Montgomery Switch, Caldwell County, Ky. Lateral aspect of upper tooth, the root partially imbedded in matrix.
- Fig. 26. *Fissodus inaequalis* (St. J. and Worth.) Lateral aspect of same specimen as shown in Pl. 2, Fig. 11.
- Fig. 27. *Petalodus alleghaniensis* Leidy. Posterior (inner) face of same specimen as shown in Pl. 2, Fig. 17.
- Fig. 28. *Homacanthus delicatulus*, sp. nov. Kinderhook limestone; Le Grand, Iowa. Spine referred to the first dorsal fin of a very small individual. An enlarged view of the same specimen is shown in Pl. 5, Fig. 59.
- Fig. 29. *Stethacanthus erectus*, sp. nov. Kinderhook limestone; Le Grand, Iowa. Left lateral aspect of fragmentary spine.
- Fig. 30. *Sagenodus cristatus*, sp. nov. Coal Measures; Mazon Creek, Grundy County, Illinois. Oral surface of dental plate.
- Fig. 31. *Elonichthys disjunctus*, sp. nov. Coal Measures; Mazon Creek, Grundy County, Illinois. Complete but somewhat distorted individual.

The originals of Figs. 25 and 28 are preserved in the Museum of Comparative Zoölogy at Cambridge; those of Figs. 24, 26, and 27, in the Museum of Nebraska State University; of Fig. 29 in the United States National Museum; and of Figs. 30 and 31 in the Museum of Yale University.

### PLATE 4.

- Figs. 32-34. *Chomatodus inconstans* Newb. and Worth. Keokuk limestone; Keokuk, Iowa. Coronal surface, anterior face, and transverse section of tooth,  $\times \frac{3}{2}$ .
- Figs. 35, 36. *Orodus intermedius*, sp. nov. Missourian; Weston, Platte County, Missouri. Anterior aspect and coronal surface of tooth,  $\times \frac{3}{2}$ .

- Fig. 37. *Deltodus contortus* (St. J. and Worth.). Lower Carboniferous limestone; Visé, Belgium. Posterior dental plate referred to the right ramus of the lower jaw, viewed from the postero-lateral margin,  $\times \frac{1}{2}$ .
- Fig. 38. *Deltodus occidentalis* Newb. and Worth. Keokuk limestone; Keokuk, Iowa. Posterior dental plate referred to the right ramus of the lower jaw,  $\times \frac{1}{2}$ .
- Fig. 39. *Phoebodus dens-neptuni*, sp. nov. Keokuk limestone; Keokuk, Iowa. Outer coronal face,  $\times \frac{1}{2}$ .
- Figs. 40, 40 a. *Phoebodus knightianus*, sp. nov. Florence Flint, Chase formation (Permo-Carboniferous); Blue Springs, Gage County, Nebraska. Lateral and anterior aspects of imperfect crown, showing prominent projection of the base in the median line in front,  $\times \frac{1}{2}$ .
- Fig. 41. *Deltodus spatulatus* Newb. and Worth. Keokuk limestone; Keokuk, Iowa. Posterior dental plate referred to the right ramus of the lower jaw.
- Fig. 42. *Deltodus spatulatus* Newb. and Worth. Burlington limestone; Burlington, Iowa. Posterior dental plate referred to the right ramus of the lower jaw,  $\times \frac{1}{2}$ .
- Fig. 43. *Deltodus contortus* (St. J. and Worth.). Coronal surface of same specimen as shown in Fig. 37,  $\times \frac{1}{2}$ .

The originals of Figs. 35-43 are preserved in the Museum of Comparative Zoölogy; the single tooth represented in Figs. 32-34 belongs to the United States National Museum.

#### PLATE 5.

- Fig. 44. *Physonemus pandatus*, sp. nov. Kinderhook limestone; Burlington, Iowa. Lateral aspect of spine,  $\times \frac{1}{2}$ .
- Fig. 45. *Physonemus hamus-piscatorius*, sp. nov. Kinderhook limestone; Burlington, Iowa. Lateral aspect and cross-section of exerted portion of spine,  $\times \frac{1}{2}$ .
- Fig. 46. *Physonemus hamus-piscatorius*, sp. nov. Kinderhook limestone; Burlington, Iowa. Exserted portion of spine in lateral aspect, with rugose distal extremity, and a portion of the substance removed by fracture, exposing tubular pulp-cavity,  $\times \frac{1}{2}$ . A tooth of *Helodus biformis* N. and W. is imbedded in the same block of limestone in immediate juxtaposition to this spine.
- Fig. 47. *Erismacanthus barbatus*, sp. nov. Kinderhook limestone; Burlington, Iowa. Fragmentary spine with rudimentary anterior branches,  $\times \frac{1}{2}$ .
- Fig. 48. *Coelacanthus exiguus* Eastm. Coal Measures; Mazon Creek, Grundy County, Illinois. Complete individual of average size,  $\times \frac{1}{2}$ .
- Fig. 49. *Elonichthys perpennatus* Eastm. Coal Measures; Mazon Creek, Grundy County, Illinois. Complete fish, probably of a young individual, with downwardly flexed caudal fin, fine fulcra on the pectorals, and impressions of the axis showing through the delicate squamation,  $\times \frac{1}{2}$ .
- Fig. 50. Tuberculated dermal plate belonging to an undetermined Elasmobranch. Kinderhook limestone; Burlington, Iowa,  $\times \frac{1}{2}$ .

- Fig. 51. *Platysomus circularis* Newb. and Worth. Coal Measures; Mazon Creek, Grundy County, Illinois. Complete fish with well-preserved fins and squamation,  $\times \frac{2}{3}$ .
- Fig. 52. *Cheirodus orbicularis* (Newb. and Worth.). Coal Measures; Mazon Creek, Grundy County, Illinois. Complete fish with well-preserved fins and dorsal and ventral peaks,  $\times \frac{2}{3}$ .
- Fig. 53. *Deltodus occidentalis* Newb. and Worth. (var. *D. latior* Newb. and Worth.). Keokuk limestone; Keokuk, Iowa. Posterior dental plate referred to right ramus of the lower jaw.
- Figs. 54, 54 a, 54 b. *Helodus incisus*, sp. nov. Mississippian; Salem, Indiana. Supposed symphyseal tooth corresponding to the form known as "*Helodus coxanus*" Newb. Seen in anterior, posterior, and lateral aspects,  $\times \frac{1}{2}$ .
- Fig. 55. *Deltodus spatulatus* Newb. and Worth. Burlington limestone; Burlington, Iowa. Anterior dental plate referred to the left ramus of the lower jaw, and described by Messrs. St. John and Worthen as a distinct species ("*D. convolutus*"),  $\times \frac{1}{2}$ .
- Fig. 56, 56 a. Tuberculated dermal plate of an undetermined Elasmobranch. Kinderhook limestone; Burlington, Iowa. The unsymmetrical cross-section near the base is shown in Fig. 56 a,  $\times \frac{1}{2}$ .
- Fig. 57. A spiniform dermal tubercle of the same nature as that shown in Fig. 56, the external surface much corroded and displaying the fibrous internal structure,  $\times \frac{1}{2}$ .
- Fig. 58. *Homacanthus acinaciformis*, sp. nov. Chemung Group; Warren, Pennsylvania. Lateral aspect of spine lacking inserted portion,  $\times \frac{1}{2}$ .
- Fig. 59. *Homacanthus delicatulus*, sp. nov. Kinderhook limestone; Le Grand, Iowa. The same spine as shown in Plate 3, Fig. 28, four times enlarged.

The originals of Figures 48, 51, and 52 are preserved in the Peabody Museum of Yale University; the remainder in the Museum of Comparative Zoölogy.